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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON 25, D. C.

DEC 17 1953

AFDRQ-TA/F

SUBJECT: (Uncl) Final Letter on Project No. APG/ADA/43-F-1

TO: All recipients of
Project APG/ADA/43-F-1

1. Air Proving Ground Report No. APG/ADA/43-F-1, "Combat Suitability Test of F-86F-2 Aircraft with T-160 Guns", dated 3 August 1953, has been reviewed by this Headquarters.

2. The conclusions contained therein are concurred in and the recommendations are approved.

a. Reference paragraph 5a(1) which recommends that consideration be given to the inclusion of the T-160 20mm gun in future fighter aircraft.

(1) The T-160 gun is presently scheduled for the F-86H, F-100 and F-101 aircraft, and is being considered for the F-105.

b. Reference paragraph 5a(2) which recommends that the problems associated with engine compressor stalls be resolved prior to the acceptance of the T-160 gun for future aircraft.

(1) The problems associated with compressor stalls are being investigated by ARDC on a high priority basis. Based on information available from results of present flight testing, it is the opinion of ARDC that these problems will be resolved before the first production aircraft with T-160 guns is taken into the Air Force inventory.

c. Reference paragraph 5a(3) which recommends that six to eight seconds of fire be provided in future aircraft equipped with T-160 guns.

(1) The F-86H will be provided with seven seconds of fire; the F-100, 11 seconds; the F-101, 15 seconds.

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d. Reference paragraph 5a(4) which recommends the development of tracer ammunition for the T-160 gun.

(1) A requirement has been established for tracer ammunition for the T-160 gun. In addition, a requirement for an armor piercing round has also been established. It is estimated that these rounds will be available for test at AFAC in January 1954, and will be in production about September 1954.

e. Reference paragraph 5a(5) which recommends that a suitable reticle camera installation utilizing the features of the Zoomar erector head be provided in future fighter aircraft.

(1) An aircraft modification proposal for the substitution of 5/8" wide Zoomar Lens Assembly in place of the present sight reticle camera lens adaptor is being processed in accordance with AFR 57-4.

f. Reference paragraph 5a(6) which recommends that a more effective system of quality control of components be provided for the T-160 gun.

(1) A copy of the subject report was forwarded to AMC for resolution of quality control problems on the T-160 gun with the Ordnance Corps, Department of the Army.

g. Reference paragraph 5a(7) which recommends that an objective training program be initiated to fulfill the training requirements for the T-160 gun.

(1) T-160 guns have been received by ATRC and training has been included in the regular Weapons Mechanic Course, No. 46250.

h. Reference paragraph 5a(8) which recommends installation of a selector switch to permit firing of either two or four guns.

(1) Action has been initiated to process this modification proposal in accordance with AFR 57-4.

BY ORDER OF THE CHIEF OF STAFF:

PLEASE NOTE:
This Approval Letter has been reproduced by Hq. Air Proving Ground Command. It should be made a part of your copies of the project it refers to.

B. K. HOLLOWAY
Brigadier General, USAF
Deputy Director of Requirements

AF- EGLIN AFB, FLA.

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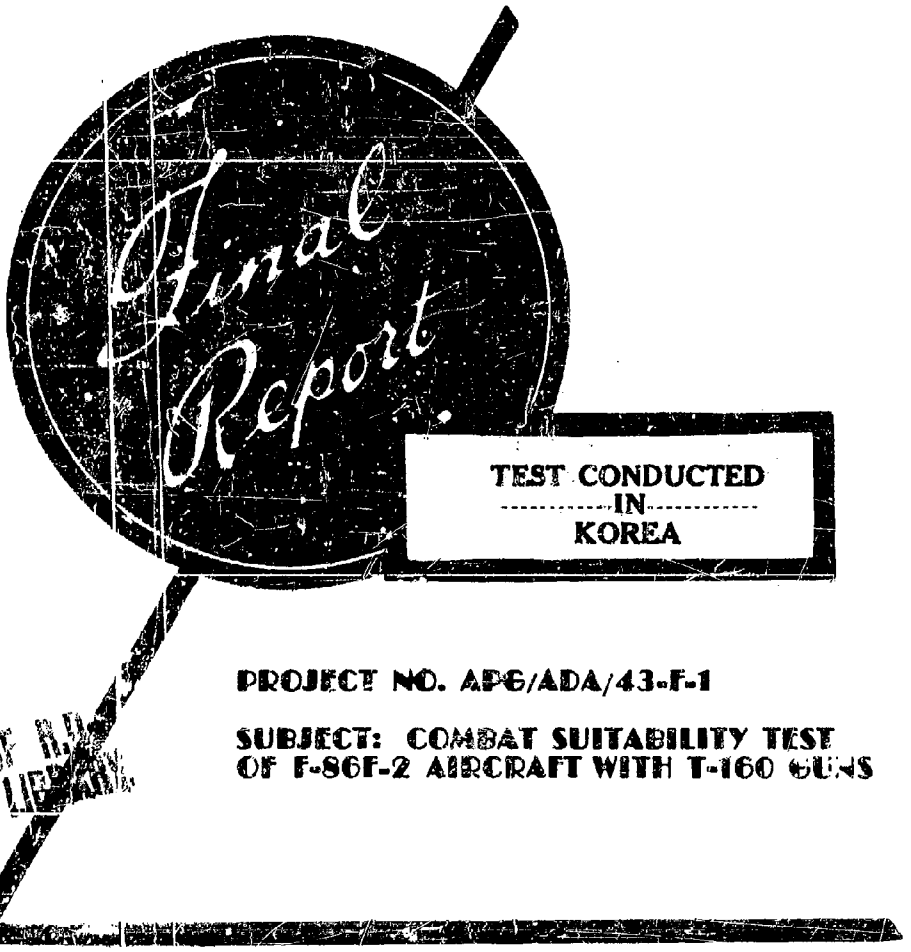
Air Proving Ground Command



TEST CONDUCTED
IN
KOREA

PROJECT NO. APG/ADA/43-F-1

SUBJECT: COMBAT SUITABILITY TEST OF F-86F-2 AIRCRAFT WITH T-160 GUNS

DATE 3 AUGUST 1953 **COPY NO.** 16 of 345

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SECURITY INFORMATION

HEADQUARTERS
AIR PROVING GROUND COMMAND
Eglin Air Force Base, Florida

SECRET
By authority of Comdr
Air Proving Ground
Command
3 Aug 53
(Date) (Initials)

3 August 1953

COMBAT SUITABILITY TEST OF F-86F-2 AIRCRAFT WITH T-160 GUNS

PROJECT NO. APG/ADA/43-F-1

1. Attached hereto is the Final Report on Project No. APG/ADA/43-F-1, the object of which was to determine the operational capabilities and limitations of the F-86F-2/T-160 gun installation and to assess the impact this new weapon may have on the Air Force. This project was conducted in Korea, under the operational control of FEAF.

2. The F-86F-2 gun installation included four T-160 20 mm guns with a total ammunition capacity of 460 rounds (approximately 4½ seconds of fire). The T-160 gun is a revolver type, electrically fired weapon having a cyclic rate of 1500 rounds per minute and a muzzle velocity of 3150 feet per second.

3. Air Force operational experience and studies of weapon effectiveness have indicated the requirement for a fighter weapon of higher kill potential than afforded by our present caliber .50 armament system. The 20 mm T-160 gun with its related ammunition has the potential of providing the Air Force with a reliable weapon to meet this requirement. This is based on pilot opinion, analysis of the effect of enemy HE ammunition on our aircraft, studies of terminal effectiveness of similar ammunition conducted in the past, and effect of the T-160 ammunition against ground targets. The weight penalty in the aircraft and the cost to the Air Force in terms of personnel and support requirements are considered acceptable in view of the weapon's higher kill potential.

4. The test installation was not suitable for combat due to the limited quantity of ammunition and the occasional occurrence of engine compressor stall while firing the guns. These major deficiencies and other problems of a less serious nature must be corrected in any production installation.

5. In view of the above considerations it is recommended that this weapon be given extensive consideration in the selection of armament systems for future fighter aircraft.

Patrick W. Timberlake

PATRICK W. TIMBERLAKE
Major General, USAF
Commander

SECRET
SECURITY INFORMATION

HEADQUARTERS
AIR PROVING GROUND COMMAND
Eglin Air Force Base, Florida

FINAL REPORT

ON

COMBAT SUITABILITY TEST OF F-86F-2 AIRCRAFT WITH T-160 GUNS

PROJECT NO. APG/AAC/43-F-1

TABLE OF CONTENTS

1. INTRODUCTION:

The Air Proving Ground Command was directed by Headquarters USAF to conduct a combat test of the T-160 gun as installed in F-86F-2 aircraft to determine its operational suitability under actual combat conditions. This project is one phase of a comprehensive test program involving the evaluation of several new designed guns installed in various fighter aircraft.

Ten aircraft were manufactured with this installation. Eight of these were committed to this program. During the period of 8 - 24 October 1952, these aircraft were received from North American Aviation, Inc. and were delivered to Edwards Air Force Base, California where a shakedown test of the installation was conducted to minimize the possibilities of functional deficiencies reflecting unfavorably on combat test results of the gun installation. The results of these shakedown tests indicated that the installation had reached an acceptable state of reliability to be committed for combat test (Reference APG Report APG/ADA/43-A-1).

To minimize the possibility of failure of any of the new components and to insure a comprehensive evaluation, a test team was formed. Team members were composed of qualified personnel from APGC, ARDC, TAC, ATRC, WADC, Aberdeen Proving Ground, North American Aviation, Inc., Ford Motor Company, Sperry Gyroscope Company and General Electric Company.

The test was conducted in Korea under the operational control of the Far East Air Forces, with the assistance and participation of personnel from the 4th Fighter Interceptor Wing. The flying phase of this program was conducted during the period of 16 January 1953 through 1 May 1953.

The installation in the aircraft included four T-160 guns, each provided with 115 rounds of ammunition (approximately 4½ seconds of fire). The 20 mm T-160 gun is a revolver type, gas operated, belt fed, electrically fired weapon which has a cyclic rate of 1500 rounds per minute and a muzzle velocity of 3150 feet per second. The ammunition provided for the gun includes an API, HEI and a practice round. This weapon was designed to provide increased effectiveness against air-to-air and air-to-ground targets.

2. OBJECT:

The object of this test program was to determine the operational capabilities and limitations of the installation and to assess the requirements imposed on the Air Force by the use of this new weapon. The following factors were considered in this evaluation.

Because of the volume of the data collected, details concerning each factor considered have been included in the Appendices.

a. Accuracy

b. Terminal Effectiveness

c. Aircraft Performance Penalty

d. Ammunition Quantity

e. Tactics

f. Reliability

g. Training Requirements

3. OPERATIONAL ASPECTS:

a. Capabilities and Limitations:

(1) Accuracy:

(a) Harmonization, Boresighting and Fire-in:

All aircraft were harmonized and fired in on a 1,000 foot range using API ammunition. The range facilities at the test site precluded the use of a longer range for fire-in. The installation features provided for boresighting and firing-in of the guns are critical. Too much time and effort (20 to 30 man-hours) is required to obtain acceptable dispersion patterns. (The procedure used and the results of each individual aircraft are attached as Appendix C.)

(b) Increased Muzzle Velocity:

The increase in muzzle velocity provided with this ammunition results in a decrease in time of flight of the projectile relative to the .50 caliber M-8 ammunition. The value of this decrease with this ammunition is in the order of 6% to 7%. Due to the large variables in altitude, air speed and range of firing during the combat test, it was not possible to validly assess the effect on accuracy implied by this increase in muzzle velocity. It is considered

reasonable to assume that this is an advantage; however, it is obvious that this small improvement becomes lost when considering the larger variables, such as, the pilot's ability to track accurately, the poor response of the aircraft at extreme altitude, etc.

(c) Requirement for Tracer Ammunition:

The pilots flying these test missions were unanimous in their opinions that there exists a requirement for tracer ammunition for this new weapon. This is most apparent in fighter versus fighter combat since oftentimes a pilot does not have time for accurate and effective tracking. To meet this operational requirement during this test, the API ammunition was dipped in beeswax which provided a smoke trace. Although the procedure of dipping the ammunition was time-consuming and the trace left by the beeswax was not of sufficient range, it did serve to fill the demands to a limited degree.

(d) Air-to-Air Firing:

During the conduct of this program, 284 combat sorties were flown. Mig-15 type aircraft were sighted on 139 sorties. Firing was accomplished on 41 occasions. Twenty of the above firings resulted in no hits observed due to extreme ranges, extremely high deflection shots or discontinuing of attacks due to engine compressor stalls. Twenty-one of the firings resulted in hits being observed on the enemy aircraft.

(e) Air-to-Ground Firing:

Six missions were flown in a rear area under controlled conditions against two standard 2½ ton army trucks and one General Sherman tank. Multiple hits were observed on each firing pass where the pilot's tracking was effective.

(2) Terminal Effectiveness:

(a) Against Mig-15 Type Aircraft:

The ammunition loading for all air-to-air

missions was alternate rounds of API and HEI ammunition. On the 21 firing occasions where hits were observed, the following claims were assessed; Six Mig-15 type aircraft destroyed; three Mig-15 type aircraft probably destroyed; and twelve Mig-15 type aircraft damaged. Although the gun camera film obtained from these missions was above average in quality, it was impossible to readily assess the damage inflicted by each round on the enemy aircraft. The Institute for Air Weapons Research is charged with the responsibility of terminal ballistics assessment. The data from their assessment will be published in a supplemental test report. (Appendix D, Part 1, includes a summary of the conditions of each of the engagements where the enemy aircraft was fired on. Part 2, Appendix D, shows the effectiveness on one Mig-15 at 43,000 feet.)

(b) Against Trucks:

Both HEI and API ammunition were found to be effective against trucks. The multiple damage imposed by each HEI round indicates that this ammunition was much more effective than the API. Single pass attacks against well defended ground targets, such as trains, airfields, etc., will be much more effective with aircraft equipped with this gun and its related ammunition. This will enhance the Air Force capabilities to effectively destroy these type targets. This is an important consideration in the tactics utilized in this type attack. (A pictorial presentation of the damage sustained to trucks is included in Appendix D, Part 3.)

(c) Against Tanks:

Neither the HEI nor API round appeared to be very effective against tanks. The penetration of one API round on the tank mantle was measured and found to be 1-1/8". This would not have been effective since the thickness in this area is approximately 4 inches. Some damage was caused to the bogie wheels by API and HEI rounds. Since there was no track on the target tank, it

was impossible to determine if this would have stopped the tank. Pictures of the damage sustained are included as Part 4, Appendix D.

(d) Effectiveness of Enemy HE Ammunition Against F-86 Aircraft:

Since damaged or destroyed Mig-15 aircraft were not recoverable, evidence of the destructive capability of the HE ammunition can be obtained by observation of the severe battle damage sustained by two of the Gun Val aircraft when each was struck by one HE projectile from enemy aircraft.

On the first case the damage was caused by a 23 mm HE shell which detonated in the fuselage fuel tank and in the second case, damage was caused by one 37 mm HE shell which struck in the lower rear portion of the fuselage. Damage inflicted by the HE ammunition in both cases clearly indicates the desirability of the HE round. (Pictures of the damage sustained are included as Part 5, Appendix D.)

(3) Aircraft Performance Penalty:

(a) Ceiling and Rate of Climb:

The weight of the test aircraft was increased by 230 pounds over F-86F-15 aircraft and by 275 pounds over F-86F-10 aircraft operating in the same tactical unit. There was no noticeable difference in performance observed up to 43,000 feet. However, above this altitude, it was the consensus that there was a small penalty in rate of climb and in the absolute ceiling of the aircraft.

(b) Deceleration When Firing Guns:

The deceleration while firing the guns in this installation was noticeably greater than that observed while firing F-86F's with the .50 caliber installation. This deceleration becomes more apparent and less acceptable when a

longer burst is fired.

(4) Ammunition Quantity:

As stated in the introduction, the test installation provided for 115 rounds of ammunition per gun with the cyclic rate of 1500 rounds per minute. This afforded approximately 4.5 seconds of fire. This quantity of ammunition is considered inadequate for the type combat experienced in Korea. Although effective damage was inflicted on 21 Mig-15 type aircraft during this test, it should not be overlooked that the caliber of pilots flying these tests was high by Air Force standards. Six to eight seconds of fire with this installation is considered to be the minimum acceptable.

(5) Reliability:

(a) Armament:

Three hundred sixty-three air firing missions were flown during the conduct of the test; 284 were air-to-air combat sorties, 6 air-to-ground sorties and 73 gun gas test sorties. A total of 108,893 rounds of ammunition were loaded with 98,135 rounds fired for a total fire out of 90%. During the last 65,000 rounds fired, a fire out of 93.2% was achieved. During this firing 210 stoppages occurred, giving a stoppage rate of 2.2 per thousand rounds fired. During the last 65,000 rounds fired, 99 stoppages occurred for a stoppage rate of 1.5 per thousand rounds fired. This reliability was achieved through the use of rigid inspections and a great amount of preventive maintenance. (Note: It must be kept in mind that the test equipment was committed to this combat test very early in the development cycle. There were several examples of poor quality control of gun components and related items. As an example, a portion of the anti-double feed switch assemblies were improperly manufactured, improper outside dimensions of gun barrel, improper dimensions of drum support, ammunition without propellant, etc.) A complete breakdown of the stoppages encountered is set forth in Appendix E.

(b) Fire Control:

The fire control system was completely operational on 92% of the missions as reported by the pilots. The radar did not function properly on 6.5% of the missions. The radar and manual ranging systems were both inoperative on only 1.5% of the missions. There was no evidence that the increased forces imposed on the aircraft by this new weapon caused any adverse effects on the fire control system. The metal flex computer shock mounts reduced the reticle vibration to an acceptable value. A detailed account of the operation of the fire control system is included as Appendix F.

(c) Reticle Camera Installation:

The reticle camera installation in these aircraft which included the Zoomar erector head was found to be desirable and effective. The installation of the camera in an inverted position and the requirement for an additional set of lens in this erector head caused the resulting image to appear inverted. This is undesirable and should be corrected by arranging the camera in an upright position. (See Appendix G)

(d) Aircraft:

There was no evidence that other components of the aircraft had been adversely affected by the armament installation.

(6) Compressor Stalls Encountered While Firing Guns:

At frequent and unpredictable times while firing the guns above 35,000 feet, large flashes were observed forward of the gun muzzle. These flashes were of varying intensity and at times extended well forward of the aircraft. Of the 363 missions flown, there were 20 occasions where the pilots reported an engine compressor stall accompanying the large flash observed while firing the guns. Six of these occurred while firing at enemy aircraft and necessitated the discontinuance of the attack. Early in the test program, one aircraft was lost due to conditions associated with this engine compressor stall problem. Although several fixes were attempted, none proved suitable.

The phenomenon associated with this problem, although not fully understood, is being investigated by the aircraft manufacturer, the Ordnance Department and responsible Air Force agencies. (Complete data on the conditions under which these engine compressor stalls were experienced is included in Appendix H.)

b. Organizational Impact:

(1) Personnel:

The weight of the T-160 gun, the increased maintenance demands, and the problems of boresighting and harmonization will make it necessary to increase the number of armament personnel in the tactical unit utilizing this equipment by an estimated 50% over the present authorization, if present concepts of utilization of aircraft are to be achieved. This increase in personnel should be made in the weapon mechanics and apprentice weapon mechanics field.

(2) Training:

Although the basic principle of this gas operated type gun is very simple, special emphasis must be placed on the training of weapon mechanics in basic electricity in order to insure proper maintenance of the armament electrical system associated with the gun. (A suggested training syllabus for the T-160 weapon is inclosed as Appendix I.)

(3) Maintenance:

To obtain maximum reliability of this weapon during the Korean test, a great amount of preventive maintenance was accomplished, in the form of rigid inspections and replacement of parts sometimes prematurely. Unless better quality control of spare parts and engineering improvements are made in the gun electrical system, this weapon will impose a far greater maintenance work load on the using organization than is presently required in the .50 caliber M-3 installation. If improvements are made in these two general areas, it is reasonable to assume that the increase in maintenance work load will be small and therefore acceptable.

(4) Facilities:

The following additional facilities will be necessary to support this new weapon:

(a) Additional tie-down facilities for boresighting, harmonization and firing-in.

(b) An increase in armament shop facilities, in the form of additional bench area, larger cleaning tanks and greater storage area.

(c) The facilities required for the storage and handling of HEI ammunition.

(d) In addition to the above, it is desirable that an 1000 foot harmonization and fire-in range be available which would permit a more accurate harmonization of the guns. (Reference Appendix C - "Harmonization and Fire-in Procedure.")

(5) Equipment:

Aside from the normal authorization of tools and equipment for an armament section of a tactical organization, it will be necessary to add a number of special tools (Reference Inclosure 10 to Appendix E). The tools authorized for weapon mechanics as outlined in ECL #10-46-1 should be amended.

c. Tactics and Techniques:

(1) Operational Tactics:

(a) Reduced Time of Fire:

The reduced time of fire with this installation makes it necessary for the pilot to be ever conscious of the need to close to an effective range before firing; however, it was found that when in effective firing range, the length of burst necessary to cause effective damage was decreased over that required with the .50 caliber installation. (See Appendix D, Part 1) To continue combat use of the installation after encountering compressor stall problems, the firing circuit was so modified as to allow

the pilot to select either the upper two guns or all four guns for firing. The selection was made by a two position switch in the cockpit. In addition to the engine compressor stall consideration, this arrangement increased the length of fire in the installation. Most pilots flying the installation felt that this was a desirable addition to the armament system. When it was impossible to close to the desired range, the pilot then felt that he could afford to expend some of his ammunition in an attempt to hit the enemy aircraft and slow him down so that an effective rate of closure could be obtained. The use of this arrangement requires that the pilot be ever conscious of the position of this switch. The selection of two guns for the purpose mentioned above is very desirable; however, on reaching an effective range, a higher hit probability would be expected when firing all four guns. The above mentioned arrangement would also be very effective when utilized against multiple lightly defended ground targets such as convoys, trains, etc.

(b) Expended Ammunition Cases:

The expended ammunition cases from the guns are disposed of overboard. This has presented no change in tactics for missions flown during this test. There are few, if any, tactical situations which require that accompanying aircraft fly directly below the firing aircraft. As long as the wing man is aware that expended cases are being disposed of directly below the firing aircraft, this should present no problem.

(2) Maintenance Techniques:

To achieve optimum reliability, the maintenance techniques utilized during this test were in the form of standard operating procedures and che lists to insure that personnel errors had as little effect as possible upon the reliability of the weapon. (A listing of these S.O.P.'s and check lists are included as Inclosure 8 to Appendix E.)

d. Collective Analysis:

In analyzing the capabilities of the present .50 caliber armament installation to meet the requirement of inflicting effective damage on present day air-to-air and air-to-ground targets, it is obvious that a more effective armament system is needed. It is apparent that the ammunition related to the T-160 20 mm gun has a much greater terminal effectiveness than that attained with the .50 caliber ammunition. The damage inflicted with each striking round is many times greater than with our present weapon.

The increase in terminal effectiveness, and the high cyclic rate, are considered the important factors which make the additional weight of this installation a reasonable and acceptable compromise.

The length of fire in this test installation is considered inadequate; however, it is considered feasible from an engineering standpoint to increase the quantity of ammunition in future aircraft. The inclusion of a selector switch to permit firing of either two guns or four guns as mentioned in paragraph c, (1) (a) above, would provide a desirable feature.

The compressor stall problem associated with this armament installation makes the installation unacceptable for combat use. The problems associated with this phenomenon must be resolved before the installation can be considered acceptable.

If adequate quality control of spare parts, engineering improvements of the gun electrical system and an objective training program for personnel are achieved, the increase in maintenance requirements in the tactical unit will be acceptable.

The cost to the Air Force in terms of logistic support, increase in facilities and training requirements are considered reasonable and acceptable in view of the increased effectiveness provided by the inclusion of this new weapon in future fighter aircraft.

4. CONCLUSIONS:

a. It is concluded that:

(1) A four gun T-160 20 mm installation with its related ammunition has the potential of providing the Air Force with a more effective armament system than that provided with the present six gun .50 caliber installation.

(2) The F-86F-2 aircraft equipped with T-160 guns used in this test are not suitable for combat use, due to the problem associated with engine compressor stall.

(3) The quantity of ammunition provided in this test installation is not adequate.

(4) A selector switch to provide pilot selection of either two guns or all guns increases the length of fire; however, this arrangement would only be advantageous in certain tactical situations since the hit probability would be greatly reduced when only firing two guns.

(5) The time required for harmonization - boresighting - fire-in is unacceptable.

(6) Based on the unanimous opinion of the twenty-six experienced pilots participating in this project, there exists a requirement for tracer ammunition for this weapon for use in fighter vs fighter combat as experienced during Korean operations.

(7) The increased forces imposed on the aircraft by this weapon have had no adverse effects on other components of the aircraft.

(8) The sight reticle camera installation with the Zoomar erector head is considered acceptable.

(9) The present USAF armament training program does not provide the armorer with a sufficient knowledge of basic electricity to adequately maintain this weapon.

(10) Present quality control of gun components is inadequate.

5. RECOMMENDATIONS:

a. It is recommended that:

(1) Consideration be given to the inclusion of the T-160 20 mm gun in future fighter aircraft.

(2) The problems associated with the engine compressor stalls be resolved prior to the acceptance of this weapon in future fighter aircraft.

(3) A minimum of six to eight seconds of ammunition be provided in future aircraft equipped with this weapon.

(4) A tracer ammunition be developed for this weapon, and that an investigation be made as to the desirability of its use.

(5) A suitable reticle camera installation utilizing the features of the Zoomar erector head be provided in future fighter aircraft.

(6) A more effective system of quality control of gun components be provided for this new weapon.

(7) An objective training program be initiated to fulfill the training requirements for this new weapon.

(8) Improvements in the electrical system of the gun be initiated as indicated in Appendix E.

Patrick W. Timberlake

PATRICK W. TIMBERLAKE
Major General, USAF
Commander

APPENDIX A

DESCRIPTION OF TEST EQUIPMENT

(Reference Photos #1 & #2 Inclosure #1)

Test Aircraft

The test aircraft utilized in this test were F-86F-2 aircraft with four T-160 20 mm guns, mounted in the fuselage, two on each side. The guns were mounted on their side, with the top facing outboard and being inclined approximately 80 degrees from the vertical. The test aircraft were similar to standard F-86F aircraft with the exception of the installation of extended leading edges instead of slats. The leading edge extended 6 inches at the wing root and three inches at the tip. The installation included the J47-27 engine and the MA-3 Fire Control System.

Modification

Prior to initiation of this test, the MA-3 fire control system was modified to include a range limiter which enhances the pilot's ability to properly track the target, indicates radar lock-on and acts as an in-range indication to the pilot. Also included in the modification was a radar sensitivity control which permitted the pilot, while in flight, to peak his radar by adjusting the lock-on sensitivity.

T-160 20 mm Gun

The T-160 gun is a revolver type, gas operated, automatic weapon consisting essentially of a combination drum support and barrel, a rotating drum with five chambers, a spring loaded operating slide, and a gas operated piston. It is electrically fired and belt (link) fed and can be adapted to either right or left hand feed. Accessories include a gun charger and a feeder. There is no gun heater provided, and apparently none is required. The T-160 gun is basically the same, in general appearance and function, as the caliber .60 T-130 gun, differing chiefly in the drum and barrel. Other designed military characteristics are as follows:

Rate of Fire . . . . . 1500 rounds per minute.

Weight of Gun (plus feeder). . 162 pounds

Length of Gun . . . . . 72 inches

Width of Gun . . . . . 8.58 inches

Height of Gun. . . . . 8 inches

Length of Barrel . . . . . 53.56 inches

Trunnion Reaction Maximum. . . (5,000 pounds)

Ammunition (T151 API round)

The military characteristics of the T151 API round are as follows:

Caliber. . . . . 20 mm (.60 caliber case)

Overall Length . . . . . 6.625 inches

Muzzle Velocity. . . . . 3150 feet per second

Weight (complete round). . . .58 pounds

Weight (projectile). . . . . 1600 grains

Primer (electric, propellant, natural cellulose) (IMR 4903)

Propellant Weight. . . . . 580 grains

Filler (incendiary). . . . . 100 grains

T-149 HEI round

The military characteristics of the T-149 HEI round are as follows:

Caliber. . . . . 20 mm (.60 caliber case)

Overall Length . . . . . 6.625 inches

Muzzle Velocity. . . . . 3150 feet per second

Weight (complete round). . . .58 pounds

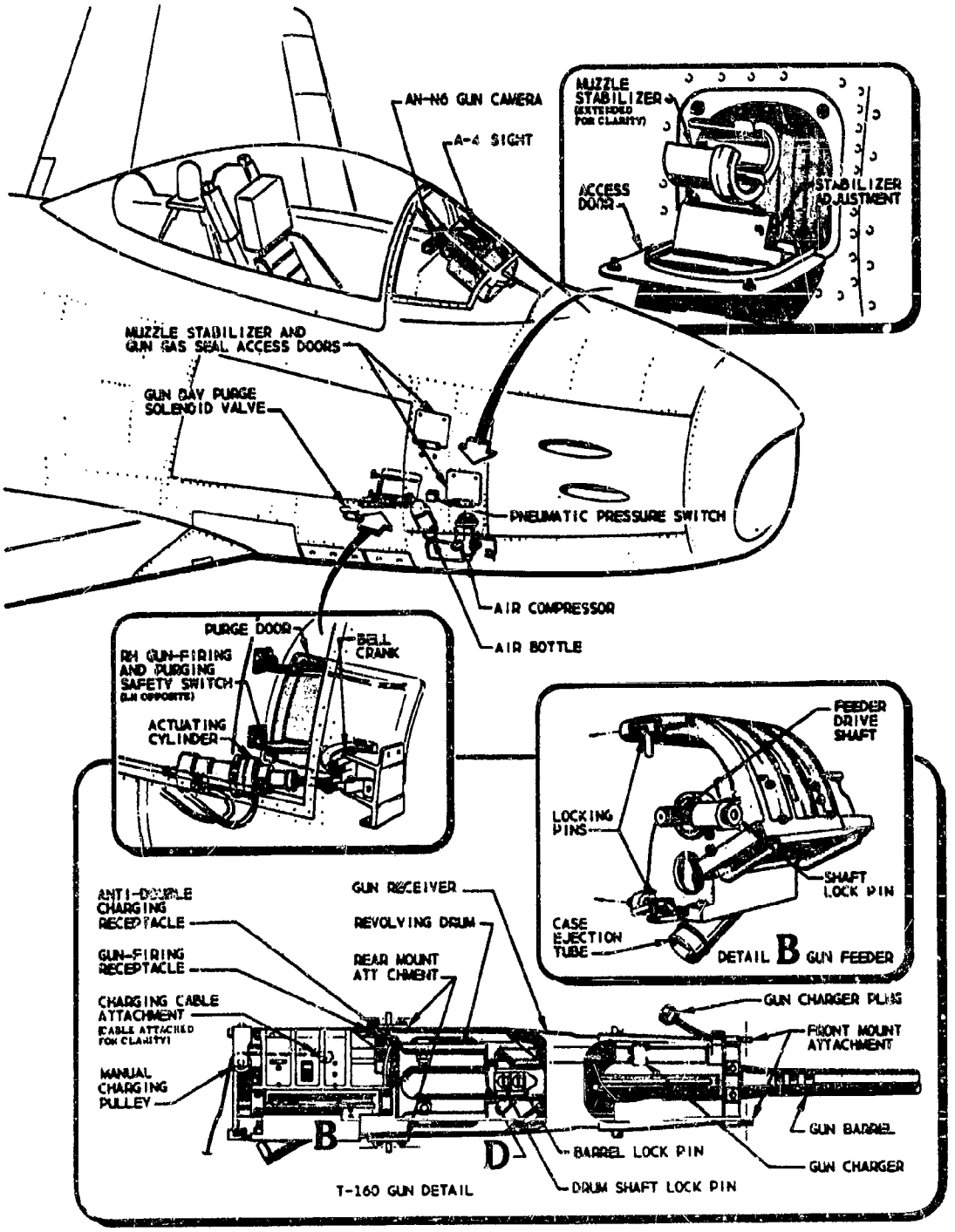
Weight (projectile). . . . . 1600 grains

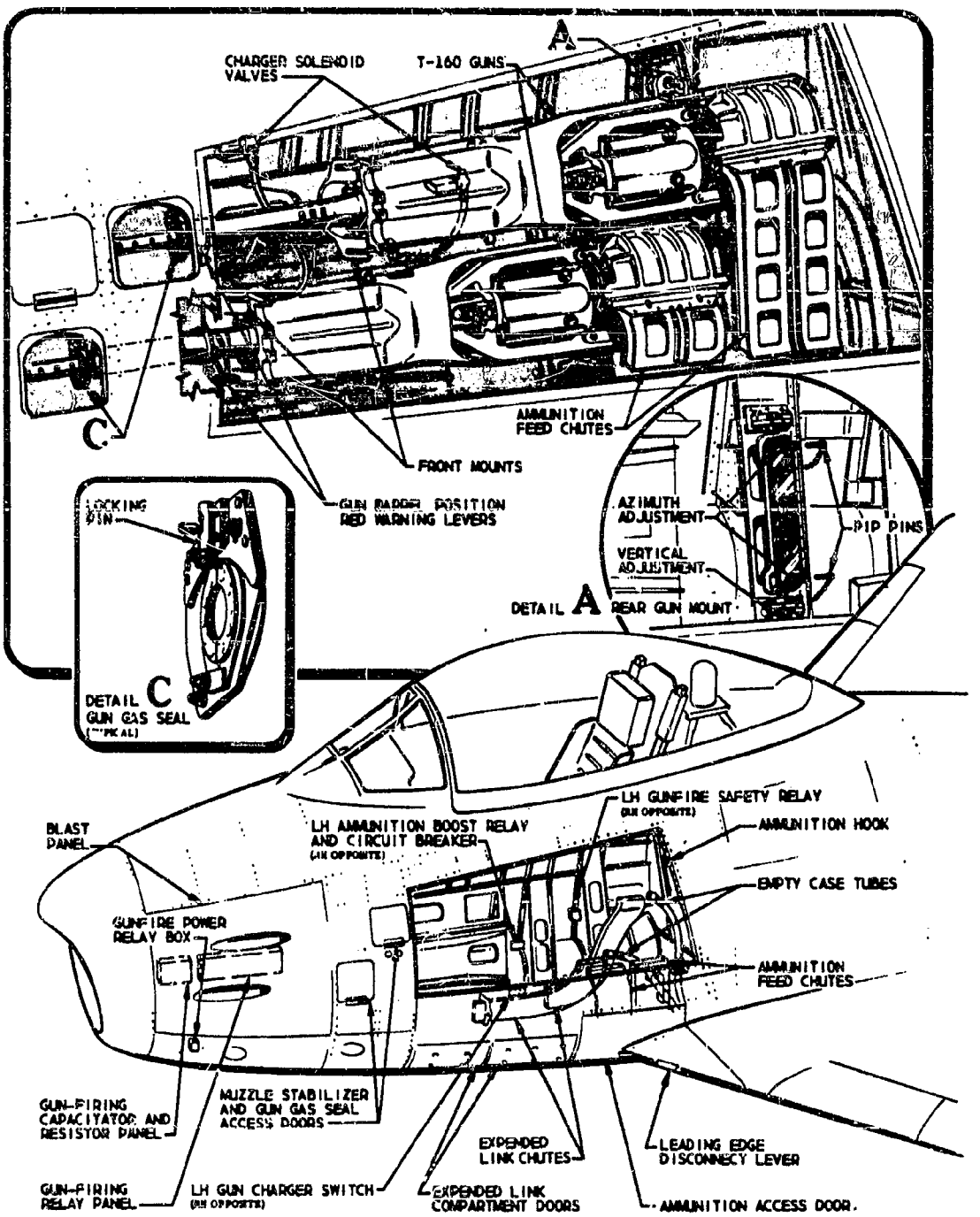
Primer (electric, propellant, natural cellulose) (IMR 4903)

Propellant Weight . . . . . 580 grains

Fuse. T-200

Filler (HEI). . . . . 110 grains


AN-N6 GUN CAMERA
A-4 SIGHT
MUZZLE STABILIZER
(EXTENDED FOR CLARITY)
ACCESS DOOR
STABILIZER ADJUSTMENT
MUZZLE STABILIZER AND GUN GAS SEAL ACCESS DOORS
GUN BAY PURGE SOLENOID VALVE
PNEUMATIC PRESSURE SWITCH
AIR COMPRESSOR
AIR BOTTLE
PURGE DOOR
BELL CRANK
RH GUN-FIRING AND PURGING SAFETY SWITCH
ACTUATING CYLINDER
FEEDER DRIVE SHAFT
LOCKING PINS
SHAFT LOCK PIN
CASE EJECTION TUBE
DETAIL B GUN FEEDER
ANTI-DOUBLE CHARGING RECEPTACLE
GUN-FIRING RECEPTACLE
CHARGING CABLE ATTACHMENT
(CABLE ATTACHED FOR CLARITY)
MANUAL CHARGING PULLEY
GUN RECEIVER
REVOLVING DRUM
REAR MOUNT ATTACHMENT
GUN CHARGER PLUG
FRONT MOUNT ATTACHMENT
GUN BARREL
BARREL LOCK PIN
GUN CHARGER
DRUM SHAFT LOCK PIN
B
D
T-160 GUN DETAIL



T-160 Guns and Equipment

APPENDIX B

TEST PROCEDURE

1. Test Program Outline

To facilitate the conductance of this test, a test program was published. This program indicated the object of the test, the factors to be investigated and the method to be used. A copy of this test program is included as Inclosure 1.

2. Test Team

To minimize the possibility of failure of any of the new components in these aircraft and to insure a comprehensive evaluation, a test team was formed. Team members were composed of qualified personnel from Air Proving Ground Command, Air Research and Development Command, Tactical Air Command, Air Training Command, Aberdeen Proving Ground, North American Aviation, Inc., Ford Motor Company, Sperry Gyroscope Company and General Electric Corporation. A list of the members of this team is included as Inclosure 2.

3. Operations in the Tactical Unit

The aircraft were assigned to the 335th Fighter Interceptor Squadron of the 4th Fighter Interceptor Wing, stationed at K-14, Korea for the conduct of this test. This squadron was equipped with F-86F aircraft. The original plan was to replace eight of the normally assigned squadron aircraft with the eight test aircraft. This plan was carried out; however, when problems associated with engine compressor stall were encountered, in order not to interfere with the combat capabilities of this squadron, the eight Gun Val aircraft were supported as an extra flight. In view of the engine compressor stall difficulties associated with this armament installation, only the most experienced pilots were utilized in flying test combat missions. Of the 284 combat missions flown, approximately 65% were flown by project team pilots. The remaining 35% were flown by pilots from the 4th Fighter Wing.

Attached as Inclosure 3 is a presentation of a typical combat mission flown with these aircraft.

To obtain the maximum data in the shortest possible time, the aircraft were scheduled only on those missions that had the

highest probability of engaging enemy aircraft.

To insure the maximum benefits from these test missions, a pilot's debriefing outline was used on each mission where enemy contact was effected. A copy of this debriefing outline is included as Inclosure 4.

COPY

HEADQUARTERS
AIR PROVING GROUND COMMAND
Eglin Air Force Base, Florida

5 June 1952

SUBJECT: Test Program to Determine the Combat Suitability of the T-160 Gun Installation APG/ADB/43-A-1 (Korean Phase)

TO: Commanding Officer
3200th Proof Test Group
Eglin Air Force Base, Florida

1. GENERAL:

a. Introduction:

This test has been activated at the request of Headquarters USAF, to provide an evaluation of the T-160 20mm gun installation in the F-86E aircraft, under actual combat conditions.

b. Description:

(1) Test Equipment

The installation under test includes four T-160 guns installed in each of six F-86E-10 aircraft. The test aircraft incorporates the J-47GE-27 engine, A-4 GBR sights and extended leading edges instead of slats. The installation has a total ammunition capacity of 480 rounds. A complete description of each of the above items is listed in Appendix A.

(2) Test Personnel:

A test team will be formed and proceed to the Far East to conduct the operational suitability testing under the operational control of the Commanding General, FEAF. Project personnel and a portion of the testing personnel will be provided by the Air Proving Ground Command. To minimize the possibility of failure of any of the new components, Headquarters USAF has recommended that this test

team include qualified representatives from ARDC, WADC, North American Aviation Company, Sperry Gyroscope Company, General Electric Corporation, Aberdeen Proving Ground, Army Ordnance, Springfield Armory, Ford and Pontiac Automotive Corporation and Armour Research Institute. It is planned that experienced FEAF pilots and armament personnel will be invited to participate in the test, to insure a more comprehensive evaluation.

c. Classification:

Secret

d. Priority of Test:

USAF - 1A

e. Project Officer:

Major R. E. Evans

2. OBJECT:

To determine the operational capabilities and limitations of the T-160 gun installation in the F-86E aircraft and to obtain basic data concerning opportunity to fire and terminal ballastics effectiveness of the related ammunition, under actual combat conditions, to be used in determining the suitability of this installation.

3. SCOPE OF TEST:

The following factors and characteristics will be investigated and evaluated for the formulation of conclusions as to the combat effectiveness of this installation and for the assessment of basic data for use in the Gun Val program:

a. A thorough and comprehensive assessment of all film, expended during this test, will be made to determine with as much accuracy as possible, the opportunity to fire/per sortie where enemy contact is attained and the terminal effectiveness of the ammunition.

b. The over-all accuracy of the gun/aircraft installation for use in the combat situation afforded by the FEAF theater of operations.

c. Evaluation of the effects on the performance of the F-86E aircraft in its combat role, by this armament installation.

d. Techniques and tactics of operational utilization, realizing the reduced time of flight of the projectile should increase accuracy.

e. Gun/aircraft installation reliability to include field maintenance and support requirements.

4. METHOD OF CONDUCTING TEST:

a. Preliminary Phase:

(1) Formation of testing team

It is planned that a team will be formed in the tactical unit, designated by CG FEAF, composed of APGC project test personnel and pilots and armament personnel from the tactical unit.

(2) Logistic Support:

The APGC will be responsible for coordinating with AMC to insure that required supplies peculiar to the test installation accompany the shipment of the aircraft and to insure that spares common to the test aircraft and F-86 aircraft currently assigned to FEAF are available and are "earmarked" in FEAF for this project.

(3) Modification:

Fabrication and installation of the following items will be accomplished by APGC personnel.

(a) A range limiter which enhances the pilot ability to properly track the target, indicates radar lock-on and acts as an in range indication to the pilot. A more complete description is attached as Appendix A.

(b) A radar sensitivity control which permits the pilot, while in flight, to peak his radar by adjusting the lock-on sensitivity.

(4) Instrumentation:

Sight cameras, equipped with 3" lens, will be mounted on the A-4 gunsights and wired in such a manner that tracking will be accomplished by using the first position on the trigger. The

cameras will be modified, to provide a time base on the film.

(5) Preliminary Engineering and Functional Testing

Personnel from APGC in conjunction with personnel from ARDC, AMC and North American Aviation Corporation will conduct a preliminary engineering and functional test at North American Aviation Corporation to insure maximum weapons system reliability prior to shipment of the aircraft to FEAF. Attached as Appendix B is proposed minimum firing schedule.

(6) Personnel Training

All test and maintenance personnel will become familiar with pertinent directives regarding operation and maintenance of the test installation. Training at North American Aviation Corporation will be utilized to train armament personnel. The APGC project officer will present to the FEAF pilots a complete briefing on operation of test items including instrumentation prior to any flying.

(7) Descriptive Photographs

Typical ground operation scenes will be photographed with a 16mm camera from the point of view that a film report may be made if results so indicate.

(8) Boresighting and Harmonization

Boresighting and harmonization will be accomplished at sufficiently frequent intervals to insure proper alignment of the guns. Boresighting and harmonization will be accomplished in accordance with attached Appendix C.

b. Main Phase:

Inasmuch as this test is being undertaken in a combat theater in a tactical unit under the operational control of the Commanding General, Far East Air Force, it is considered impractical to outline specific missions to be undertaken. However, it is imperative that maximum information be gained from each mission flown.

(1) Accuracy phase:

Film assessment will provide data for this evaluation. The Air Proving Ground Command is providing film, a portable developer with necessary chemicals, and personnel to maintain instrumentation and develop the film. The APGC project officer will make preliminary assessment of all film as soon as possible. Each participating pilot will be required to review his film after each mission and will not fly a subsequent mission until the film has been reviewed, unless the current tactical situation warrants exception to this procedure. When in the opinion of the project officer, no further review is necessary, the film will be catalogued and correlated with the reports and forwarded to APGC.

(2) Opportunity to Fire

By providing a time base on the film it is planned that accurate information as to the opportunity to fire/per sortie flown where enemy contact is made will be obtained. By careful assessment of the film and by complete reporting by the pilot at the completion of each mission it will be possible to determine this important data, for the combat situation afforded by the FEAF theatre of operation, needed in determining the effectiveness of the installation. A periodic review of the film by the APGC project officer will be made to insure that this data is being obtained.

(3) Terminal Effectiveness

All film will be assessed to gain as much information as possible concerning terminal effectiveness. The facilities of BRL and IAWR will be utilized in the terminal effectiveness evaluation. Where possible, enemy material which is damaged or destroyed by this installation should be closely inspected to determine the terminal effectiveness of the ammunition. If possible, a representative number of controlled missions against appropriate captured enemy targets will be undertaken. Complete written and photographic results of these firings will be recorded.

(4) Aircraft Performance:

The effects on performance and maneuverability,

caused by this armament installation, will be investigated. Comments of all participating pilots will be solicited on handling characteristics, improvements in maneuvering and tracking qualities, and performance differences between the test aircraft and other F-86 aircraft in the theater.

(5) Tactics and Techniques:

The fact that the time of flight of this ammunition is less than the currently used M-8 ammunition implies than an increase in accuracy at long ranges should be achieved. Evaluation of firing tests will be made to verify or refute this assumption.

(6) Gun/aircraft installation reliability

The general reliability of each gun/aircraft installation will be obtained primarily from gun test records on the guns from each installation. It is therefore mandatory that complete and accurate gun test records be kept on each individual gun for each aircraft installation. These records will include all ammunition fired through each gun, gun malfunctions and their causes, all parts, breakages and replacements, gun maintenance requirements, and all changes and/or adjustments made to the test equipment. Gun test record forms (See Appendix D) will be provided. In addition to keeping of gun test records periodic inspections will be made for examination of each gun installation as a whole and a written report will be prepared to cover items generally not included in individual gun test records, such as: damage to aircraft components and related gun equipment; looseness of gun mounts, gun chargers, and other accessory equipment, and suggestions for modifications which may improve gun/installation reliability.

c. Final Phase:

When in the opinion of the project personnel the test data are adequate, the APGC project team will return to the Air Proving Ground. All data and exposed film will be returned and final evaluation will be accomplished. Extreme care should be taken in properly cataloging of film and mission reports.

5. RECORDS:

a. The project officer will maintain the following records:

(1) Daily log.

(2) Daily mission reports carefully correlated with the exposed film.

(3) Gun history records.

(4) A small library of film recording ground handling, loading, maintenance procedures, etc..

b. The project officer will make weekly reports to the Air Defense Branch, Operational Testing Division, D/O, APGC, giving complete data to date including film and pilots' reports.

BY COMMAND OF MAJOR GENERAL BOATNER:

5 Appendices:
A, B, C, D, & E
5 Incls to App E

s/t K. K. COMPTON
Colonel, USAF
Deputy for Operations

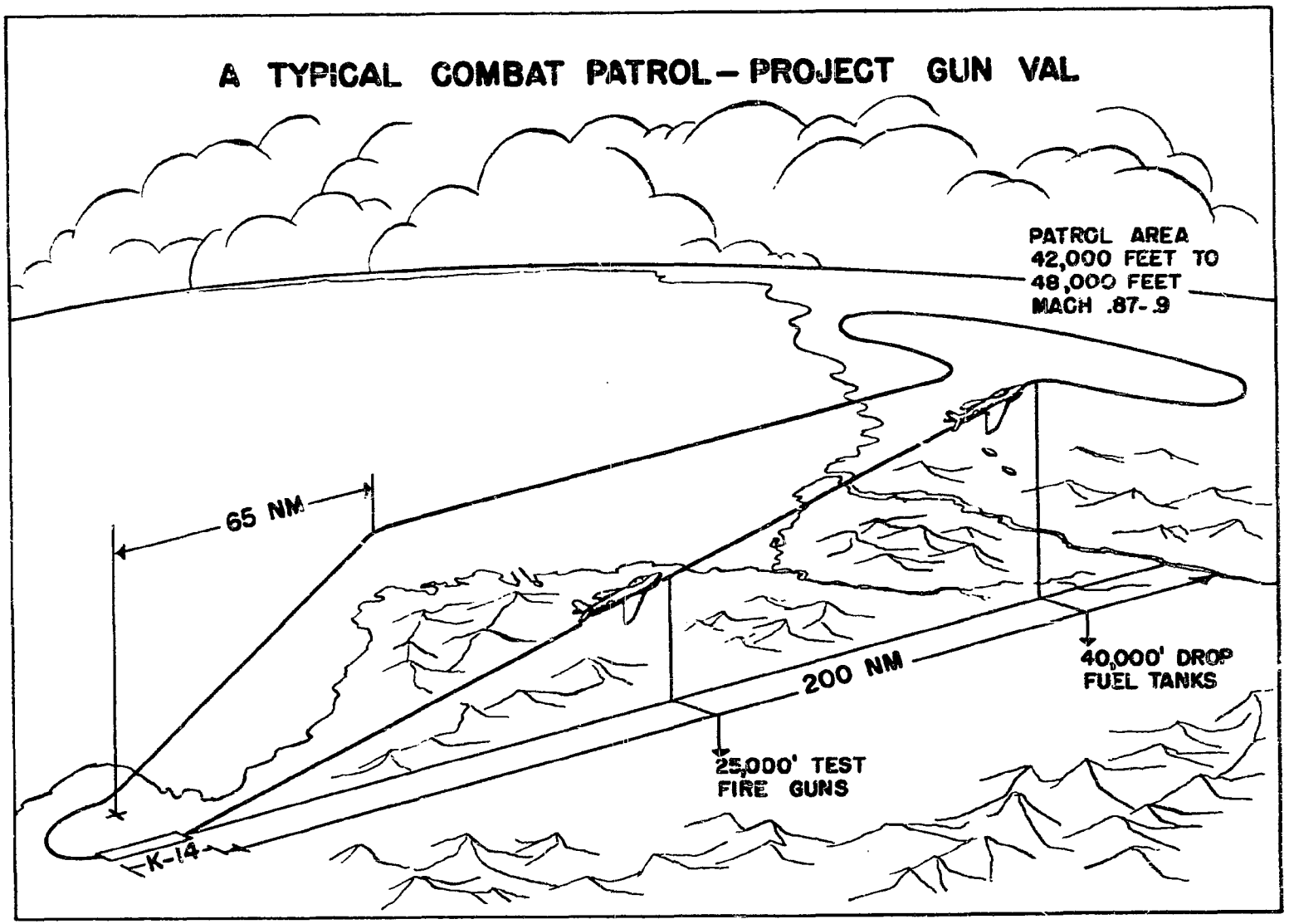
COPY

GUN VAL PROJECT TEAM

Major R. E. Evans	Air Proving Ground Command
Captain L. R. Moore	" " " "
WOJG E. W. O'Brien	" " " "
M/Sgt W. R. Beaty	" " " "
M/Sgt L. V. Gibson	" " " "
T/Sgt O. C. Kralicek	" " " "
S/Sgt J. B. McDonnell	" " " "
S/Sgt J. H. Lovejoy	" " " "
S/Sgt W. Kunie	" " " "
A/1C S. E. Olszewski	" " " "
A/1C J. C. Flaherty	" " " "
A/1C R. F. Alber	" " " "
A/1C R. W. Vanasse	" " " "
A/2C C. B. Bantel	" " " "
Colonel G. L. Jones	Air Training Command
T/Sgt Charles H. Daniel	" " "
Lt. Col. C. L. Peterson	Tactical Air Command
Lt. Col. D. L. Rodewald	Headquarters, USAF
M/Sgt Carnes	335th Ftr Intcp Sq, 4th F. I. Gp.
Major H. B. Yount	Army Ordnance Department
1/Lt. K. Main	Wright Air Development Center

CIVILIAN TECHNICAL REPRESENTATIVES

Mr. Paul F. Peterson	North American Aviation, Inc.
Mr. B. L. Rayner	Wright Air Development Center
Mr. R. Lesman	Ford Motor Company
Mr. K. Leslie	A. C. Spark Plug Corporation
Mr. O. Magrane	Sperry Gyroscope Corporation
Mr. W. Muzzy	" " "
Mr. W. S. Aumen	Naval Ordnance Department


A TYPICAL COMBAT PATROL - PROJECT GUN VAL
PATROL AREA
42,000 FEET TO
48,000 FEET
MACH .87-.9
65 NM
200 NM
40,000' DROP
FUEL TANKS
25,000' TEST
FIRE GUNS
K-14

QUESTIONS TO BE ANSWERED BY THE PILOT AT TIME HE IS DEBRIEFED BY APGC PERSONNEL

PART I (TO BE ANSWERED ON EACH MISSION)

A. General Information concerning mission

1. Date
2. Group Mission No.
3. Aircraft Number
4. Pilot's name and rank
5. Position in flight
6. Type of mission
7. Mission altitude
8. Weather
9. Contrail levels

B. Malfunctions

1. Radar
2. Sight
3. Armament

C. Performance Penalty

1. Was the extra weight of the T-160 gun installation noticeable in the climb?

2. Were your power settings higher than those of your wing man during climb out?

3. How much fuel did you and your wing man have remaining at shut down?

4. What was the maximum altitude attained? What quantity of fuel?

PART II (TO BE ANSWERED ONLY IF PILOT FIRES ON TARGET)

A. For each pass at each target on which the pilot depressed the trigger to fire, compose a narrative to include the following information.

1. Total enemy aircraft in this engagement
2. Total own aircraft in this engagement
3. Time at which each particular target was attacked
4. Target altitude
5. Estimated speed of target
6. Target type

7. Own position as seen from target
   (Clock position, hi, low, level, estimated range)
8. Own speed
9. Was sight (manual cage, electrical cage, computing off)
10. Was ranging done (preset, manually, radar)
11. Was range limiter (Off, 1200, 1800, 2400)
12. Target's tactics during pass
13. Own tactics during pass
14. Number of bursts and their approximate length
15. Approximate number of G's pulled during firing
16. Approximate range at time of firing
17. How many targets were fired on

B. Terminal Effectiveness

1. If hits were made on the target, what damage occurred?

   a. Started smoking
   b. Caught on fire
   c. Slowed down
   d. Any other observed damage
   e. Was target previously damaged
   f. Duration of attack
   g. Target last seen at (altitude, attitude and heading)
   h. Pilot's claim

2. Reasons for firing or not firing, i.e. (to destroy enemy aircraft believed to be in range, to prevent enemy aircraft from gaining position on friendly aircraft, to cause enemy aircraft to break, to damage enemy aircraft and slow him down, to damage enemy aircraft before it reaches sanctuary, other).

3. Opinion of pilot as to advantages or disadvantages of 20 mm ammunition compared to .50 caliber in this situation.

C. Length of Fire

1. Do you consider the present amount of ammunition, in length of fire, adequate for the type mission just flown?

2. If answer to above question is negative, give opinion as to what is the required amount.

D. Accuracy

1. If hits were observed on the target, where were they

in relation to where you were holding the pipper?

2. At what estimated range were the hits observed?

3. State opinion on use of tracers. Would tracers have helped in this case?

E. Change in Tactics

1. Were there any changes in tactics made because of the extra weight?

2. 3^0 depression of the guns?

3. Decrease in time of fire

4. Did your wing man have to alter his position due to the expended shells falling from your aircraft?

5. Compare this installation with .50 caliber installation while firing guns, as to reticle vibration, deceleration due to gun fire, and any other.

F. Range Limiter

1. What range was set into the range limiter?

2. Did the range limiter help you to track more accurately?

3. Was the intensity of the blinking of the sight reticle adequate so that you knew when you were within the preset range?

4. Is the range limiter desirable?

G. APG/30 Radar and Radar Lock-on Sensitivity Control

1. Was the operation of the radar satisfactory?

2. Was the lock-on sensitivity control used on this mission?

3. At what estimated ranges were you obtaining lock-ons and at what altitude?

4. Was the target selection button used?

H. A-4 Gun Sight

1. Was sight in operating condition?

2. What wing span setting was set into the sight?

3. How do you compare the A-4 with the A-1 CM gun sight?

4. With other gun sights you have used?

I. Sight Reticle Camera Installation

1. Did the camera installation hinder you in tracking the target.

2. Additional comments on the camera installation.

APPENDIX C

BORESIGHTING AND HARMONIZATION

1. INTRODUCTION:

The 8 Gun Val aircraft were boresighted, harmonized and fired in on a 1000' range at K-14. The periods of harmonization would have been more frequent had the facilities at K-14 been available more often. Each aircraft was boresighted approximately once per month, which meant the aircraft averaged approximately 22 flights between boresighting and harmonization. Dispersion patterns were obtained for all aircraft with burst patterns of 10 rounds per gun. Reference Inclosure #2 for patterns obtained. The boresighting procedure used is listed as inclosure #1.

2. RESULTS:

a. Firing in at 1800 feet would have been more desirable in that fewer target calculations would have been necessary to attain acceptable patterns. At 1800' a single point, or convergence point can be utilized for all guns, whereas at 1000' separate points for each gun was required to obtain the desired convergence at 1800'.

b. The installation features provided for boresighting or firing in these guns are critical and much more time-consuming than similar .50 caliber gun installation features. Following were the major difficulties encountered during harmonization.

(1) The T-160 gun is provided with a muzzle stabilizer to prevent barrel whip. As a result, this stabilizer, plus the gas seal, requires an adjustment as well as the rear mounts. This is a very time-consuming adjustment due to the inaccessibility of the adjustment nuts on the stabilizer supports. Once the adjustment has been made, it is equally as difficult to lock the stabilizer in place without deflecting the barrel. On occasions, the armorer was required to loosen and readjust the stabilizer supports several times for one adjustment of the gun mount.

(2) Although the rear mount adjustment features were accessible, many times the armorer made an adjustment in the wrong direction, and several patterns were fired before the error was realized. This would indicate a need for instructions or directions

for adjusting the vertical and lateral adjusting nuts. This could be done in the form of an instruction decal placed in an appropriate place near the rear gun mount.

(3) The number of tie down points and jacks required for firing in this installation is noted in Inclosure #1, "Boresight Procedure Used at K-14". Compared to the .50 caliber installation boresighted at this site, the T-160 installation required greater facilities and additional time to set up the aircraft. This was necessary due to the greater recoil forces imparted to the aircraft by the T-160 guns and due to the fact that with the boresight procedure used, all 4 guns were fired simultaneously.

c. The average time required to boresight the aircraft was reduced considerably during the latter part of the program as the personnel became more experienced and the procedure simplified. The average time to boresight 1 aircraft was 30 to 40 man hours (4 to 5 men - 6 to 8 hours).

d. It is felt that there are many factors which affect the dispersion patterns obtained with this gun installation, and of the many variables involved, it is inconclusive as to which has the greater effect. The following factors are contributable:

(1) Tie-down facilities were of poor qualities in that the tie-down rings were secured in loosely poured concrete slabs which were free to shift in the ground.

(2) The firing of the guns in various combinations produced various dispersion patterns. These various frequencies imparted to the aircraft caused the center of impact of individual guns to shift. A 4-gun dispersion pattern did not compare favorably with either the 2-upper gun or 2-lower gun patterns. It was apparent that the dispersion patterns were greatly effected by the interference of the guns on each other.

(3) The variation of barrel diameters at the muzzle stabilizers which often cancelled the effectiveness of the stabilizer in that the barrel whip increased the dispersion.

(4) The stability of the API round, used on the

boresight range, was poor. Many instances were observed where the incendiary mix in the windshield prematurely exploded, and several fired projectiles were found in the gun butts with stripped or partially stripped rotating bands. (See photo #1, Inclosure #13 to Appendix E.)

(5) Loosening of the rear mounts with life of the aircraft is to be considered although it is felt that this affects the dispersion very little.

3. CONCLUSION:

a. The adjustments required to obtain the desired dispersion were too time-consuming and not acceptable from this standpoint.

4. RECOMMENDATIONS:

a. Further study and testing be done to determine a more simplified method of boresighting and harmonization of this installation.

b. Further study be made to determine the major factor contributing to the instability of dispersion patterns.

c. Further engineering be accomplished to provide a more acceptable muzzle stabilizer arrangement.

BORESIGHT AND HARMONIZATION PROCEDURE

USED AT K-14 FIRE-IN RANGE

1. An 8' X 8' panel target with appropriate aligning marks (see Diagram #1) was placed 1000' from the airplane.

2. The aircraft was placed in its normal flight attitude (3^{0} nose up) and leveled laterally.

3. The aligning sights were installed on the aircraft and the target was positioned horizontally and vertically by aligning the sights with the cross A of the target.

4. The computer was leveled and the electrical cage sight reticle adjusted on cross C of the target.

5. The nose of the aircraft was elevated until the aligning sights on the aircraft were superimposed on cross B of the target. This additional elevation (approximately 2 mils) is required to compensate for bullet drop (22" at 1000').

6. The aircraft was tied down using steel cables with turn buckles on the nose, wing and tail positions. (Care was taken to insure that the aircraft was not malaligned with respect to the target.)

7. Using colored ammunition to distinguish gun positions, a single round was fired from both upper guns. The target was divided into four quadrants to correspond to the gun positions. If the rounds did not fall in their correct quadrant an adjustment of the gun was required. This was accomplished as follows:

a. The gas seals were unlatched and the muzzle stabilizers removed.

b. Vertical and/or lateral adjustments were made to the rear mount as required.

c. Muzzle stabilizer brackets were adjusted so that the gun barrels were not deflected when the stabilizers were repositioned.

8. Using colored ammunition to distinguish different gun positions a 10 round burst was fired simultaneously from both upper guns. If 70% of the rounds fell within the proper quadrants, the adjustment was considered satisfactory.

9. Steps No. 7 and 8 were repeated for the two lower guns.

10. Using colored ammunition to distinguish different gun positions, a 10 round burst was fired from all four guns simultaneously. If the following conditions were met the harmonization was considered satisfactory.

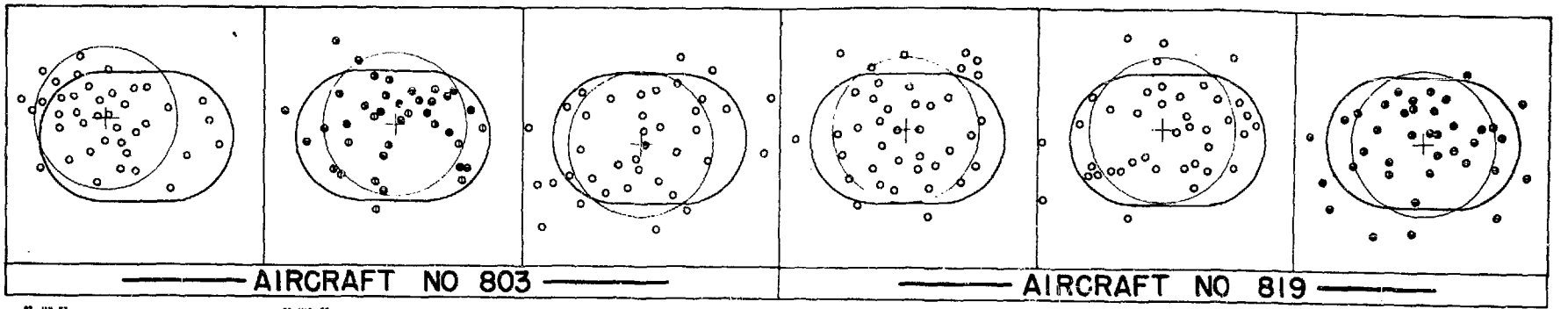
a. The majority of hits from each gun must fall within its proper quadrant.

b. 50% of the total rounds fired must fall within the 4' X 6' bull's eye.

DISPERSION PATTERNS

of

GUN - VAL AIRCRAFT AT K-14



AIRCRAFT NO 803

23 JAN 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
31 HITS IN BULL
80% HITS IN 4.5 MIL CIRCLE

28 MAR 53
L1 20 RNDS LOADED 19 HITS ON TARGET
R1 20 RNDS FIRED 16 HITS IN BULL — 80% IN 4.5 MIL CIR
L2 20 RNDS LOADED 20 HITS ON TARGET
R2 20 RNDS FIRED 17 HITS IN BULL — 60% IN 4.5 MIL CIR

28 MAR 53
40 RNDS LOADED
40 RNDS FIRED
38 HITS ON TARGET
27 HITS IN BULL
55% HITS IN 4.5 MIL CIR

AIRCRAFT NO 819

25 JAN 53
40 RNDS LOADED
40 RNDS FIRED
39 HITS ON TARGET
29 HITS IN BULL
65% HITS IN 4.5 MIL CIR

7 MAR 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
33 HITS IN BULL
60% HITS IN 4.5 MIL CIR

15 APR 53
40 RNDS LOADED
40 RNDS FIRED
36 HITS ON TARGET
29 HITS IN BULL
63% HITS IN 4.5 MIL CIR

AIRCRAFT NO 826

23 JAN 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
31 HITS IN BULL
75% HITS IN 4.5 MIL CIR

15 MAR 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
32 HITS IN BULL
56% HITS IN 4.5 MIL CIR

AIRCRAFT NO 836

23 JAN 53
40 RNDS LOADED
30 RNDS FIRED
38 HITS ON TARGET
22 HITS IN BULL
52% HITS IN 4.5 MIL CIR

15 MAR 53
60 RNDS LOADED
63 RNDS FIRED
58 HITS ON TARGET
41 HITS IN BULL
55% HITS IN 4.5 MIL CIR

AIRCRAFT NO 861

22 JAN 53
40 RNDS LOADED
37 RNDS FIRED
37 HITS ON TARGET
30 HITS IN BULL
70% HITS IN 4.5 MIL CIR

NOTES

TARGET: 8 X 8 MILS
BULL: 4 X 8 MILS
CIRCLE: 4.5 MILS RADIUS

LEGEND

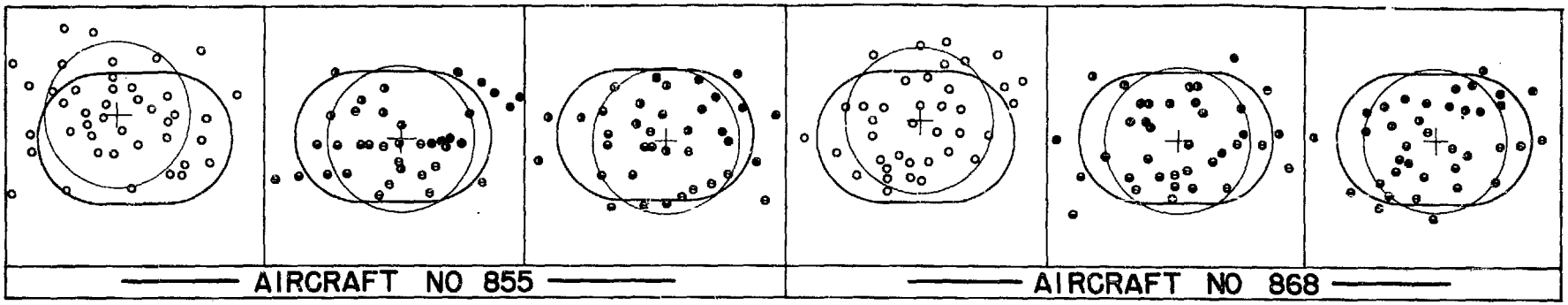
- ALL GUNS
- LEFT WG-1
- RIGHT WG-1
- LEFT WG-2
- RIGHT WG-2
- M.P.I.

0 4 8
GRAPHIC SCALE - MILS

DISPERSION PATTERNS

of

GUN - VAL AIRCRAFT AT K-14



AIRCRAFT NO 855

21 JAN 53
42 RNDS LOADED
42 RNDS FIRED
42 HITS ON TARGET
29 HITS IN BULL
57% HITS IN 4.5 MIL CIRCLE

4 APR 53
L-1 20 RNDS LOADED | 18 HITS ON TARGET
R-1 20 RNDS FIRED | 15 HITS IN BULL | 65% IN 4.5 MIL CIR
L-2 20 RNDS LOADED | 18 HITS ON TARGET
R-2 20 RNDS FIRED | 15 HITS IN BULL | 65% IN 4.5 MIL CIR

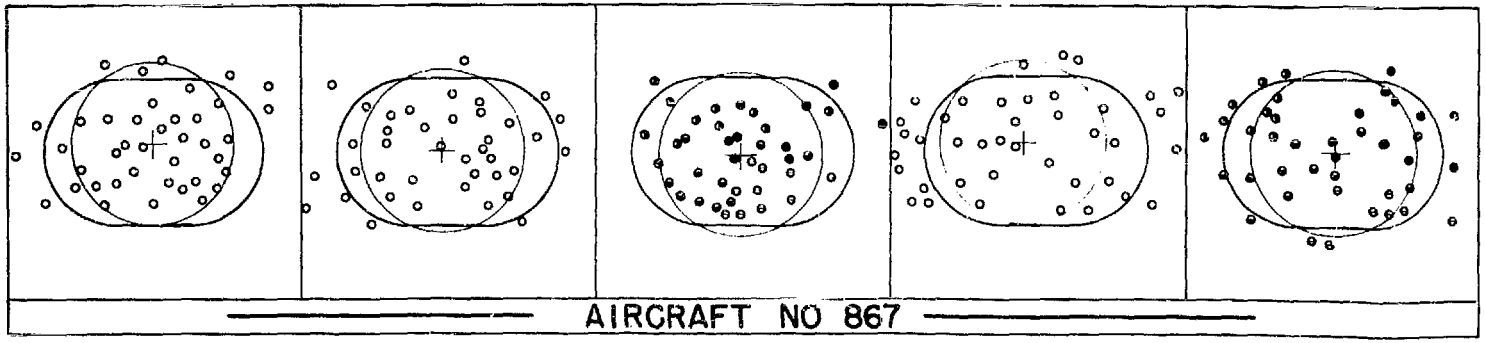
4 APR 53
40 RNDS LOADED
40 RNDS FIRED
37 HITS ON TARGET
28 HITS IN BULL
68% HITS IN 4.5 MIL CIR

AIRCRAFT NO 868

18 JAN 53
40 RNDS LOADED
38 RNDS FIRED
38 HITS ON TARGET
28 HITS IN BULL
68% HITS IN 4.5 MIL CIR

4 APR 53
L-1 20 RNDS LOADED | 18 HITS ON TARGET
R-1 20 RNDS FIRED | 14 HITS IN BULL | 65% IN 4.5 MIL CIR
L-2 20 RNDS LOADED | 18 HITS ON TARGET
R-2 20 RNDS FIRED | 15 HITS IN BULL | 65% IN 4.5 MIL CIR

4 APR 53
40 RNDS LOADED
40 RNDS FIRED
37 HITS ON TARGET
30 HITS IN BULL
65% HITS IN 4.5 MIL CIR



AIRCRAFT NO 867

18 JAN 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
31 HITS IN BULL
75% HITS IN 4.5 MIL CIR

27 FEB 53
40 RNDS LOADED
40 RNDS FIRED
39 HITS ON TARGET
29 HITS IN BULL
70% HITS IN 4.5 MIL CIR

27 MAR 53
L-1 20 RNDS LOADED | 20 HITS ON TARGET
R-1 20 RNDS FIRED | 17 HITS IN BULL | 75% IN 4.5 MIL CIR
L-2 20 RNDS LOADED | 20 HITS ON TARGET
R-2 20 RNDS FIRED | 20 HITS IN BULL | 95% IN 4.5 MIL CIR

27 MAR 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
23 HITS IN BULL
49% HITS IN 4.5 MIL CIR

21 APR 53
40 RNDS LOADED
40 RNDS FIRED
40 HITS ON TARGET
27 HITS IN BULL
55% HITS IN 4.5 MIL CIR

NOTES

TARGET: 8 X 8 MILS
BULL: 4 X 6 MILS
CIRCLE: 4.5 MILS RADIUS

LEGEND

- ALL GUNS
- LEFT NO-1
- RIGHT NO-1
- LEFT NO-2
- RIGHT NO-2
- M.P.I.

0 4 8
GRAPHIC SCALE - MILS

APPENDIX D

PART I

SUMMARY OF ENGAGEMENTS WHEN ENEMY AIRCRAFT WERE FIRED ON

PART II

DESTRUCTION OF AN ENEMY AIRCRAFT

PART III

PHOTOGRAPHS OF EFFECTIVENESS OF API & HEI AMMUNITION AGAINST TRUCKS

PART IV

PHOTOGRAPHS OF EFFECTIVENESS OF API & HEI AMMUNITION AGAINST TANKS

PART V

PHOTOGRAPHS OF DAMAGE SUSTAINED TO F-86 TYPE AIRCRAFT BY ENEMY HE AMMUNITION

APPENDIX D

PART I

SUMMARY OF ENGAGEMENTS WHEN ENEMY AIRCRAFT WERE FIRED ON

6 Destroyed

APGC Mission #50 - Major Garrison on 21 Feb 53. Pilot and wing man observed Mig to crash into hill side. No aircraft visible on film. Attack started at 30,000 feet and went on down to the deck at approximately .98 to Mach 1. 156 rounds fired.

APGC Mission #114 - Major Evans on 13 Mar 53. 15 hits were observed. 1st burst started at 1025 feet and ended at 825 feet. 2nd burst averaged 400 feet range, 3rd burst averaged 260 feet and 4th burst averaged 200 foot range. Mig pilot was observed to bail out by pilot and wing man and was also observed on film. The attack was started at 44,000 down to 17,000 feet, at .92 Mach. 389 rounds fired.

Shared credits for the destruction of one Mig-15.

APGC Mission #115 - Captain Moore on 13 Mar 53. 7 or 8 hits were observed. 1st pass was at a range of 1350 feet. All other passes at enemy aircraft were too obscure to measure. The approximate range of these passes was 2,000 feet. Mig pilot bailed out and was observed by pilot and wing man and was also observed on film. Attack started at 44,000 feet down to 15,000 feet at an air speed of approximately .92 Mach. 460 rounds fired.

APGC Mission #173 - Lt. Col. Jones on 29 Mar 53. Plane disintegrated. Range at time of firing was 775 feet. Mig pilot had ejected when aircraft was last seen. Altitude at time of firing was 42,000 feet at .85 Mach. Compressor stall occurred while firing the guns. 230 rounds were fired.

APGC Mission #206 - Lt. Col. Jones on 7 Apr 53. Head on pass at a range of 500 feet. Captain Moore observed Mig to explode at time of this engagement. Altitude was 40,000 feet at .85 Mach. 92 rounds were fired.

APGC Mission #207 - Major Evans on 7 April 53. First firing pass at a range of 1750 feet. Second firing pass at a range of 2050 feet to 3450 feet. Pilot observed Mig pilot bail out. Altitude of 28,000 feet at .92 Mach. 415 rounds fired.

APGC Mission #230 - Captain Moore on 12 Apr 53. Firing from a range of 4100 feet. Pilot and wing man observed Mig pilot bail out. Altitude of 43,000 feet at .90 Mach. 460 rounds fired. Two other Migs fired on during this mission.

3 Migs Probably Destroyed.

APGC Mission #77 - Colonel Baker on 3 Mar 53. Two hits observed. First burst at 1175 feet, 2nd at 2750 feet. Pilot observed canopy eject. Altitude of 25,000 feet at .94 Mach. 460 rounds fired.

APGC Mission #177 - Major Garrison on 29 Mar 53. First burst at 1025 feet to 775 feet. Second burst from 775 to 600 feet. Altitude of 7000 to 8000 feet at 575 KIAS. Pieces were observed by the pilot to come off the aircraft and it was last seen smoking and on its back going down in an overcast. 176 rounds were fired.

Mig Probably Destroyed

APGC Mission #230 - Captain Moore on 12 Apr 53. Firing from a range of 900 to 700 feet. Altitude of 1000 feet at .95 Mach. Fire was observed emanating from the tail section of the Mig aircraft. 460 rounds fired. Two other Migs were fired on during this mission.

Twelve Migs Damaged

APGC Mission #10 - Major Moorehead on 23 Jan 53. No aircraft visible on film. Reticle indicating approximately 4100 feet at time of firing if wing span was set at 32 feet. Altitude of 45,000 feet at .85 Mach. Pilot observed one hit. 317 rounds were fired. Compressor stall was experienced while firing guns.

APGC Mission #11 - Captain Stacy on 23 Jan 53. First firing burst at 1350 feet and 2nd at 2050 feet. Altitude of 30,000 feet at .96 Mach. Pilot observed hits. 447 rounds fired.

Migs Damaged (Cont'd)

APGC Mission #18 - Colonel Johnson on 25 Jan 53. First firing pass at the aircraft was not visible on film. 2nd firing pass at a range of 1350 feet. Third firing pass at a range of 1850 feet. Fourth firing pass at a range of 1500 feet. Complete report not obtained from pilot. Film showed one hit. 460 rounds fired.

APGC Mission #91 - Major Evans on 5 Mar 53. Fired at a range of 3,000 feet. (Only aircraft visible.) Pilot observed two hits. Altitude of 37,000 feet at 150 to 160 KIAS. 460 rounds fired.

APGC Mission #106 - Major Brady on 9 Mar 53. Film not assessable, aircraft too small. Firing was done at about 5,000 foot range pulling 3 G's. Altitude of 30,000 feet at .96 Mach. Pilot observed one hit. 460 rounds fired. Compressor stall occurred.

APGC Mission #112 - Lt. Col. Jones on 13 Mar 53. Fired at approximately 2600 foot range. Film not assessable, aircraft not visible. Wing man and another element leader in the area observed hits. Altitude of 43,000 to 44,000 feet at .78 Mach. 279 rounds fired.

APGC Mission #147 - Lt. Col. Jones on 21 Mar 53. Magazine jam on reticle camera. Wing man observed hits. Altitude of 36,000 feet at .85 Mach. 137 rounds fired.

APGC Mission #158 - Lt. Col. Peterson on 26 Mar 53. Pilot observed one hit and film showed one hit. Range of 2750 feet. Altitude of 46,000 feet at .67 Mach. 68 rounds fired.

APGC Mission #205 - Captain Moore on 7 Apr 53. No aircraft visible on film. Pilot estimated range to be between 4,000 and 5,000 feet. Altitude of 43,000 feet at .70 Mach. Pilot observed one hit. 393 rounds were fired.

APGC Mission #208 - Lt. Col. Jones on 7 Apr 53. 1st firing pass from 2,000 to 1,650 feet. 2nd firing pass from 1,650 to 2,000 feet. 3rd firing

Migs Damaged (Cont'd)	pass from 2000 to 2750 feet. Altitude of 47,000 feet at .92 Mach. Pilot observed hits and film showed hits. 314 rounds fired.
	APGC Mission #270 - Lt. Col. Keller on 24 Apr 53. Two Migs damaged. First Mig was fired on a range of 3,000 feet and pilot observed one hit but film did not show aircraft. 2nd Mig was fired on at a range of 1800 feet and the film showed one hit. Altitude was 48,000 feet at .85 Mach during both of these engagements. 250 rounds were fired.
Fourteen Firings Resulted With No Hits Observed	APGC Mission #24 - Captain Winslow on 28 Jan 53. Aircraft not visible on film. Altitude of 43,000 feet at .72 Mach. 363 rounds fired.
	APGC Mission #33 - Colonel Baker on 17 Feb 53. Mig fired on at 4,500 foot range. Aircraft not visible on film. Complete report not obtained from pilot. 106 rounds fired.
	APGC Mission #113 - Lt. Col. Peterson on 13 Mar 53. Fired at a range of 2,050 feet. Altitude of 45,000 feet with 220 KIAS. 395 rounds fired. Compressor stall occurred.
	APGC Mission #122 - Lt. Col. Jones on 14 Mar 53. Fired at a range of 1,250 feet. Altitude of 40,000 feet at .90 Mach. 89 rounds fired.
	APGC Mission #151 - Lt. Col. Jones on 26 Mar 53. Mig fired on at 2,000 foot range. Altitude of 44,000 feet at .90 Mach. 428 rounds fired. Compressor stall occurred.
	APGC Mission #156 - Captain Moore on 26 Mar 53. Less than 300 feet. Image too blurred during firing to make accurate measurement. Altitude of 43,000 feet at .87 Mach. 388 rounds fired. Fired two guns for one second burst. Guns were test fired on the return to the home base.
	APGC Mission #159 - Captain Moore on 26 Mar 53. Mig fired on at a range of 2,750 feet. Altitude of 41,000 feet at .90 Mach. 319 rounds fired. Compressor stall occurred.
	APGC Mission #161 - Major Jabara on 26 Mar 53.

No Hits Observed (Cont'd)	Extreme range. Film unassessable. Altitude approximately 40,000 feet at .87 Mach. 198 rounds fired.
	APGC Mission #183 - Captain Moore on 30 Mar 53 Mig fired on at a range of 1,375 feet. Altitude of 45,000 feet at .75 Mach. 48 rounds fired.
	APGC Mission #184 - Lt. Col. Peterson on 30 Mar 53. Mig fired on at 2,050 feet range. Altitude of 44,000 feet at .76 Mach. 108 rounds fired.
	APGC Mission #209 - Major Evans on 7 Apr 53. No aircraft visible on film. Pilot fired at an estimated range of 4,800 feet. Altitude of 41,000 feet at .86 Mach. 68 rounds fired.
	APGC Mission #245 - Captain Fernandez on 16 Apr 53. Aircraft was not visible on film. Altitude of approximately 43,000 feet at .87 Mach. 460 rounds fired.
	APGC Mission #274 - Captain Moore on 27 Apr 53. The aircraft was not visible on the film. The range at the time of firing was approximately 4,800 feet. Altitude of 43,000 feet at .90 Mach. 20 rounds fired.
90° Deflection Shots With No Hits Observed.	APGC Mission #66 - Major Evans on 5 Mar 53. Magazine jam on camera. Extreme range. No altitude or Mach listed. 460 rounds fired. One short burst fired on a Mig. Guns were test fired on the return to the home base.
	APGC Mission #116 - Major Mass on 13 Mar 53. Fired on a Mig at a 1500 foot range. Altitude of 41,000 feet at .85 or .90 Mach. 24 rounds fired.
	APGC Mission #9 - Major Garrison on 23 Jan 53. Mig was tracked and the pilot attempted to fire the guns but they would not fire. Altitude of approximately 45,000 feet at .85 to .87 Mach. 326 rounds fired on a test fire.
	APGC Mission #20 - Captain Winslow on 25 Jan 53. Mig fired on but no hits were observed. Altitude of 41,500 feet at .80 Mach. The guns were test fired on the return from the combat mission and a

compressor stall occurred which resulted in the loss of a Gun Val aircraft.

APPENDIX D

PART II

DESTRUCTION OF AN ENEMY AIRCRAFT

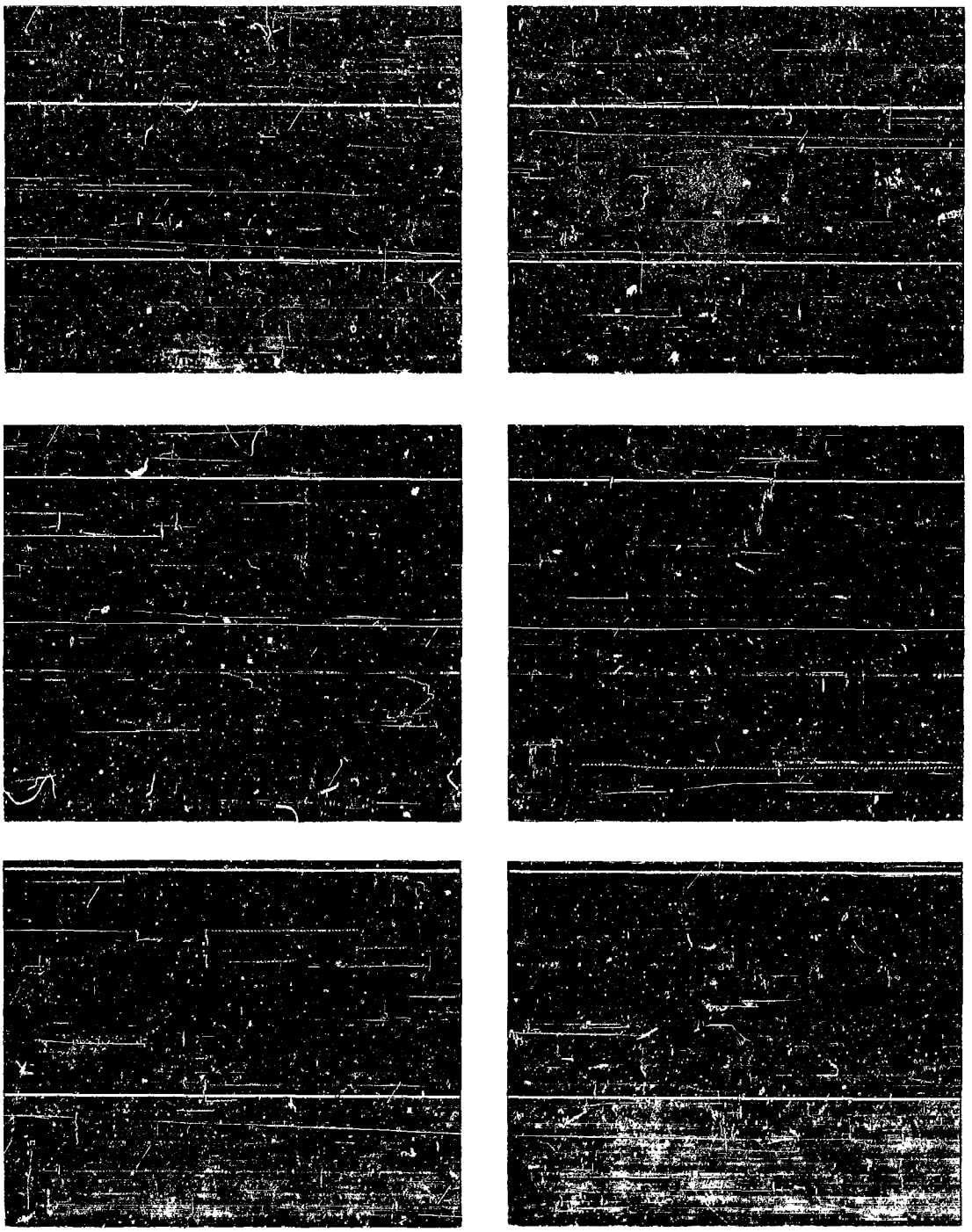
Prints from sight reticle camera film from Gun Vai aircraft showing tracking, hits and destruction of a Mig-15 type aircraft.

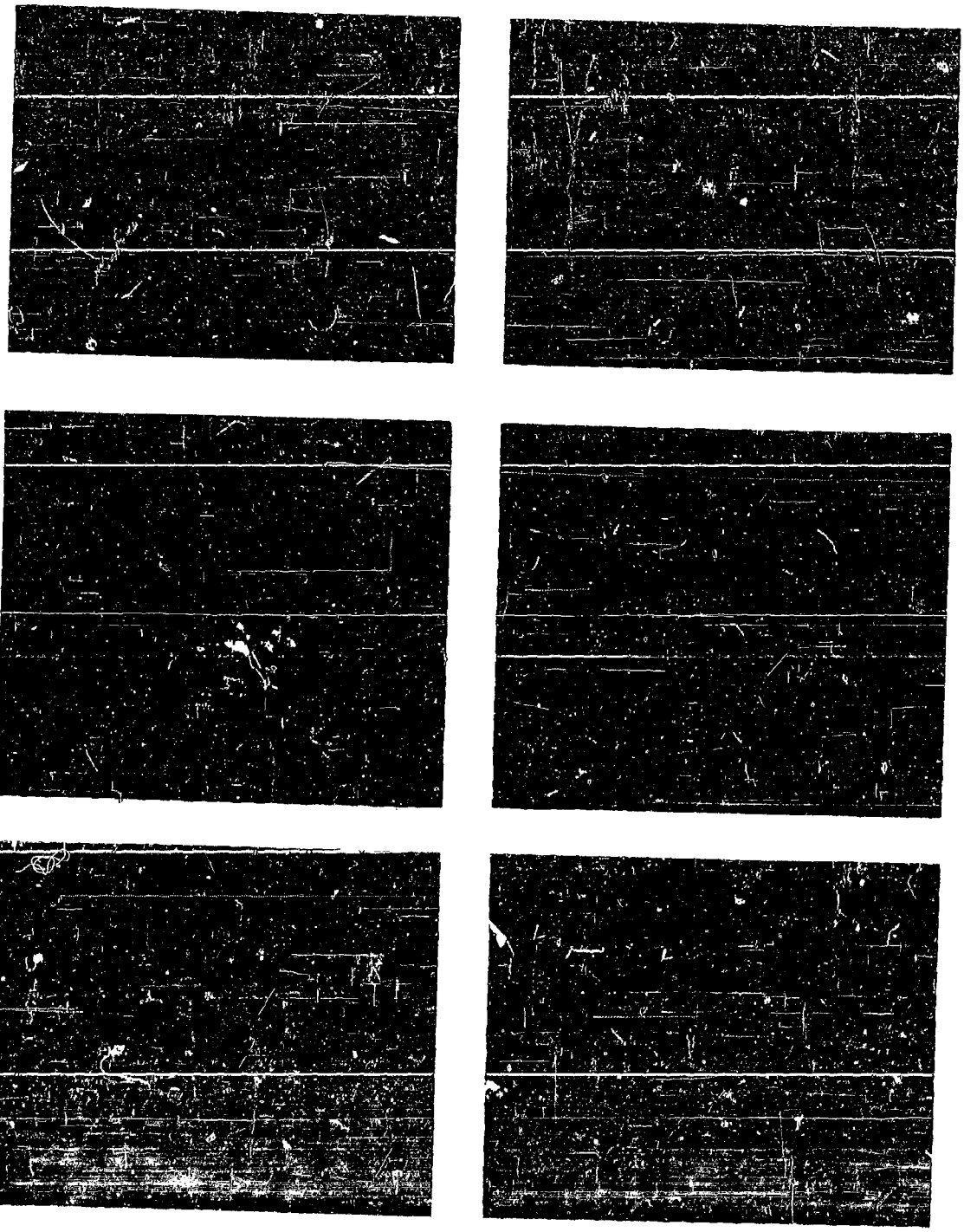
Altitude: 42,000 Feet

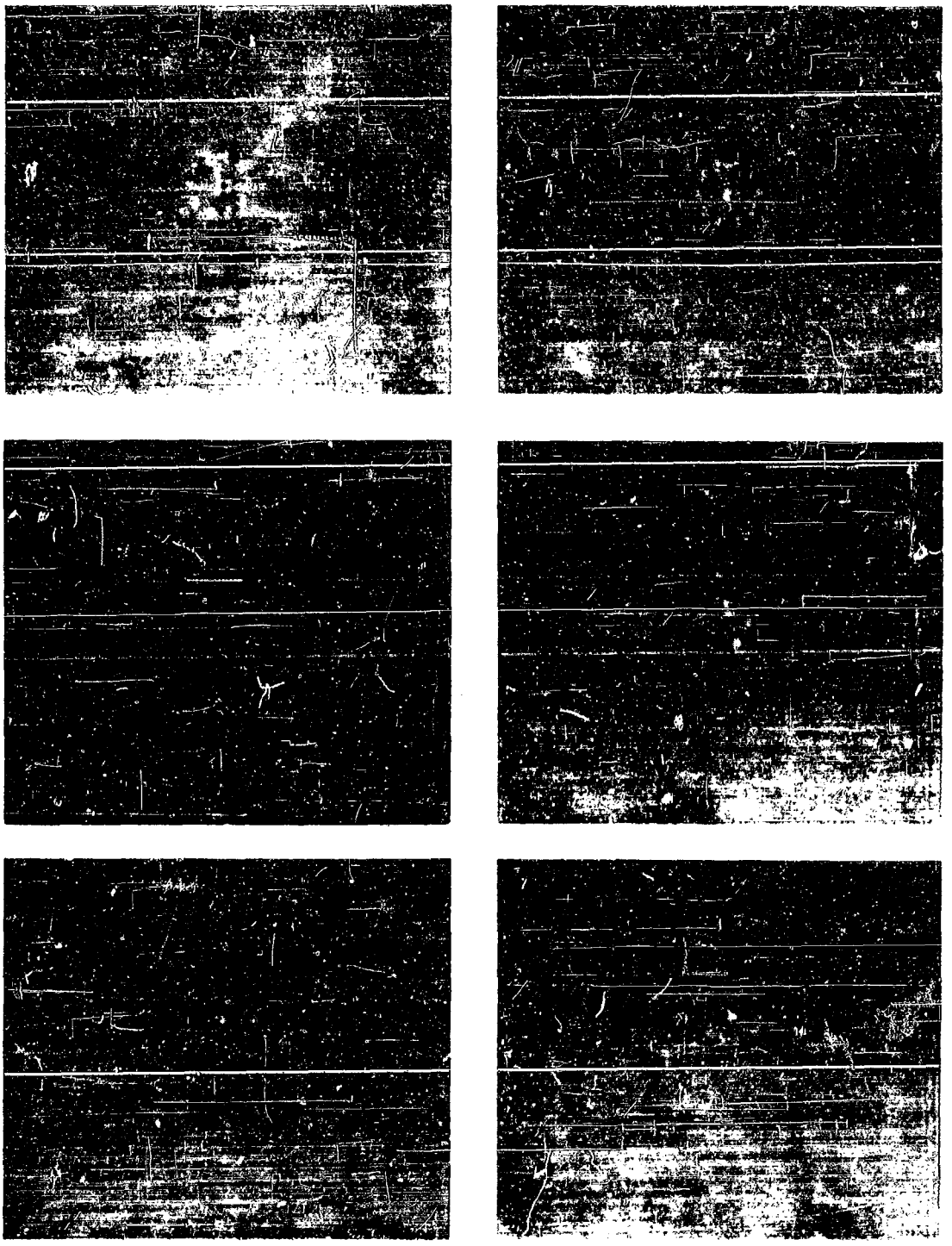
Airspeed: .85 Mach

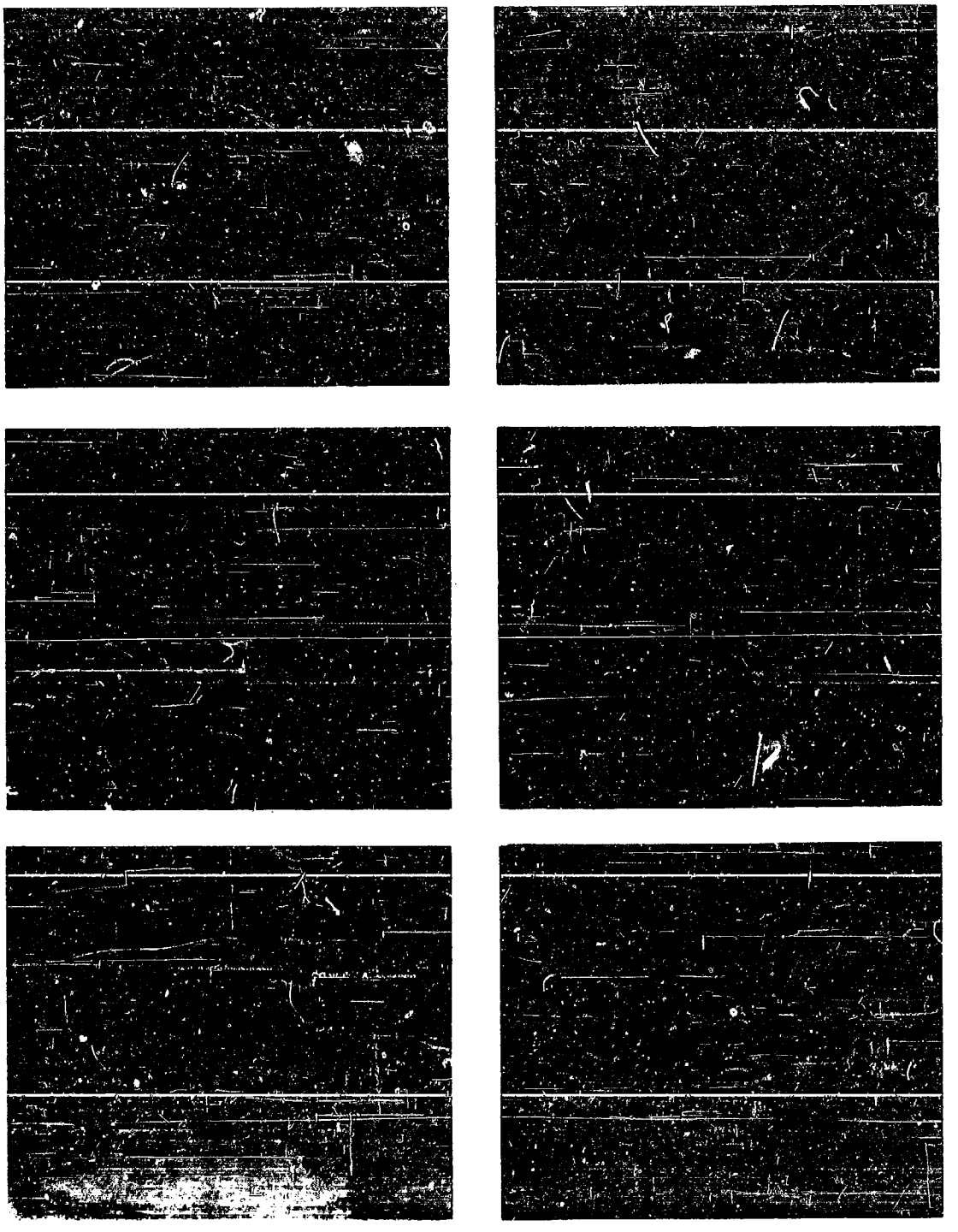
Rounds Expended: 230 Rounds

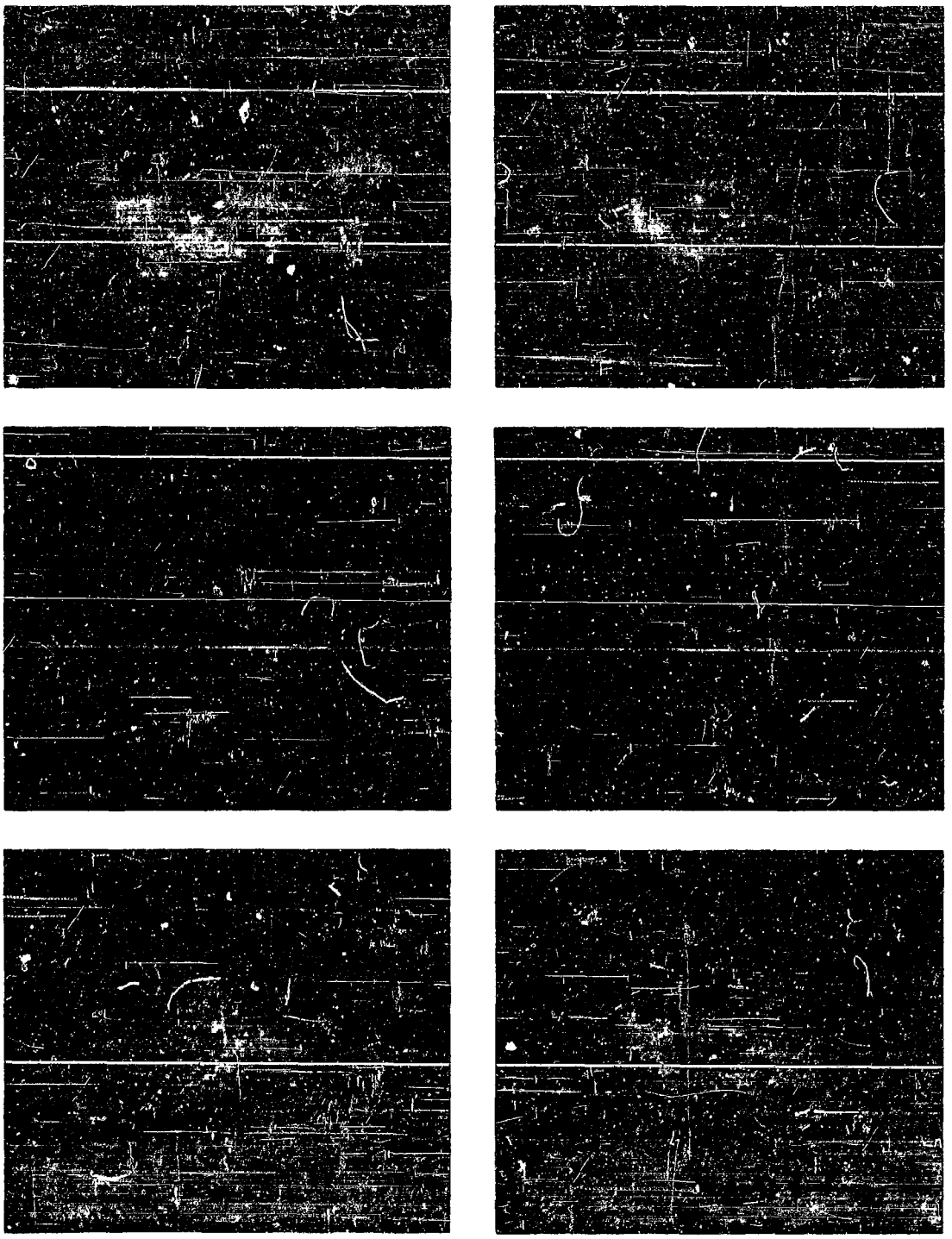
The Mig-15 was observed to explode and disintegrate after being hit.

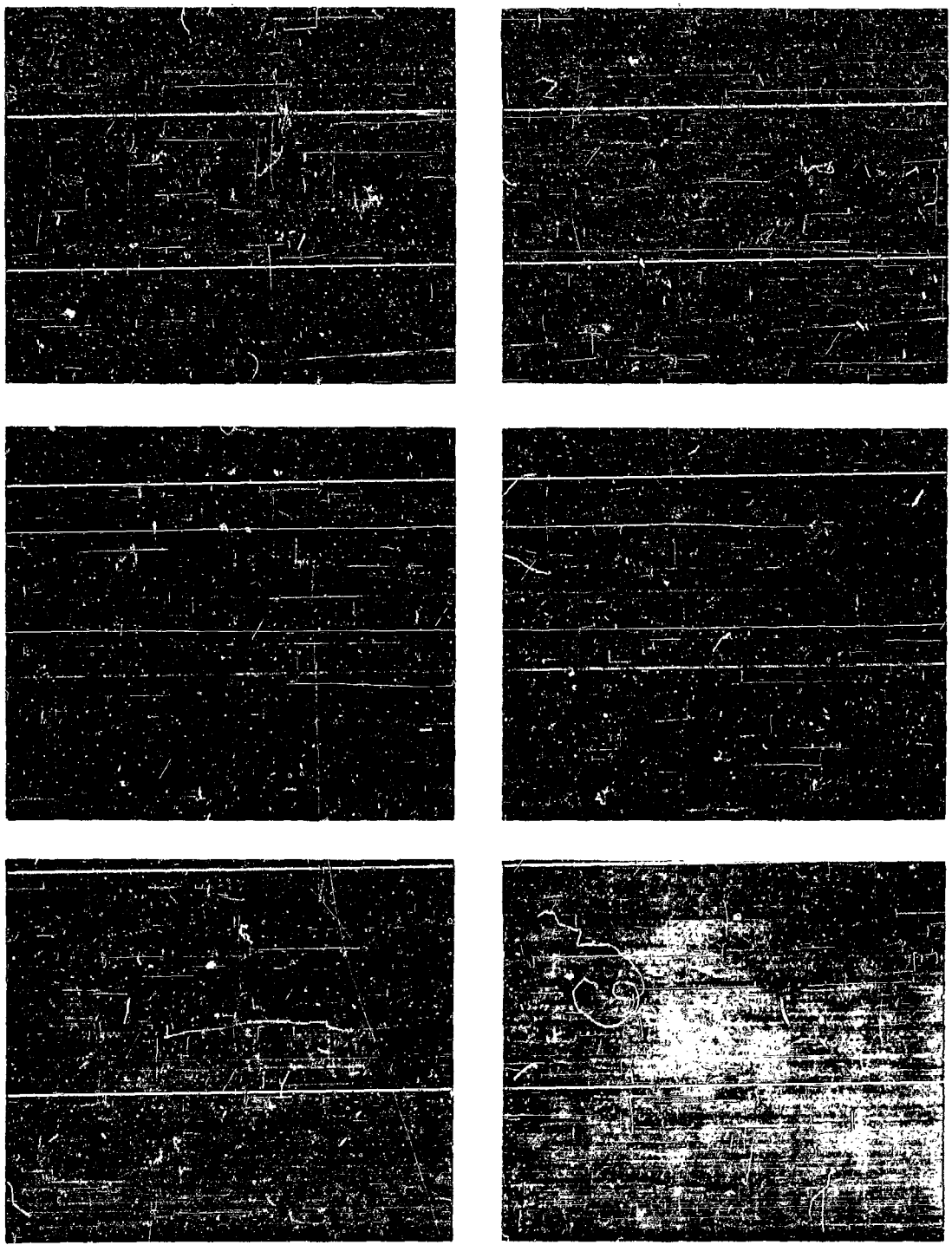












APPENDIX D

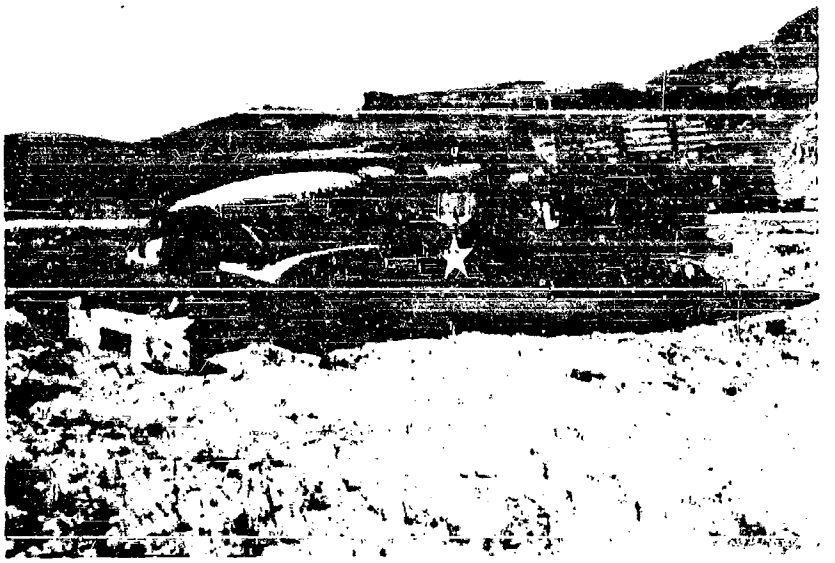
PART III

PHOTOGRAPHS

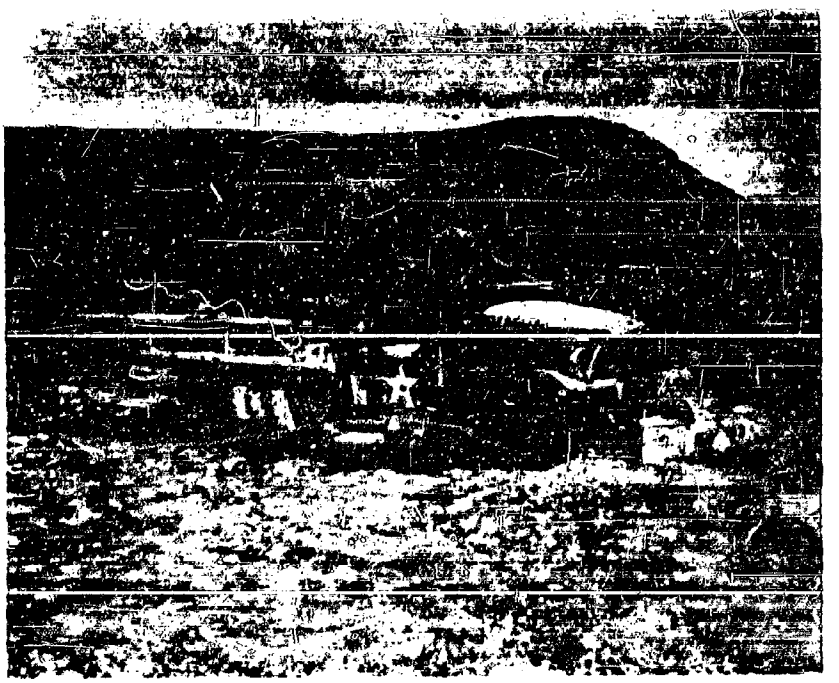
OF

EFFECTIVENESS OF API & HEI AMMUNITION

AGAINST TRUCKS

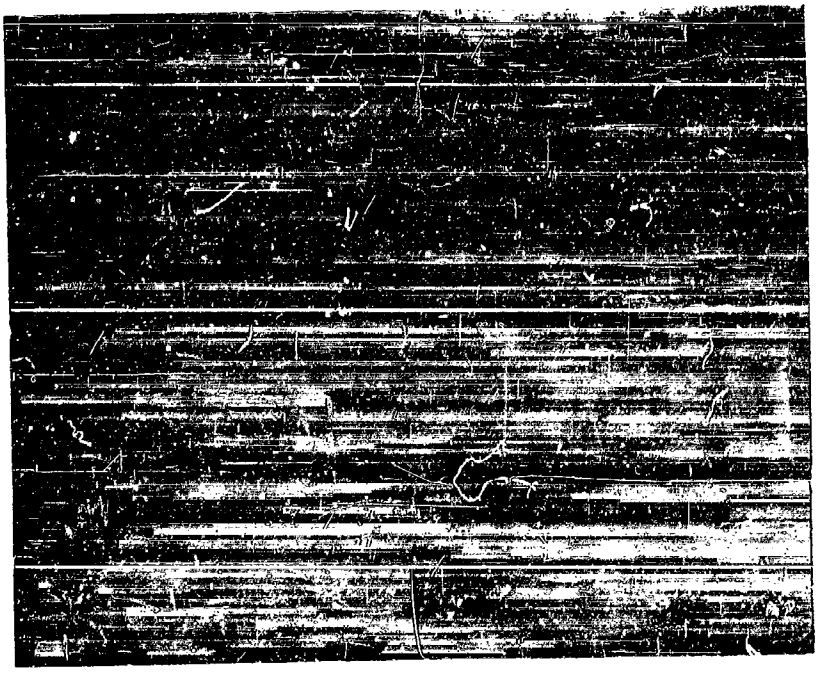


2½ TON TRUCK AFTER ATTACK - HEI



2½ TON TRUCK AFTER ATTACK - HEI

GASOLINE TANK - HEI

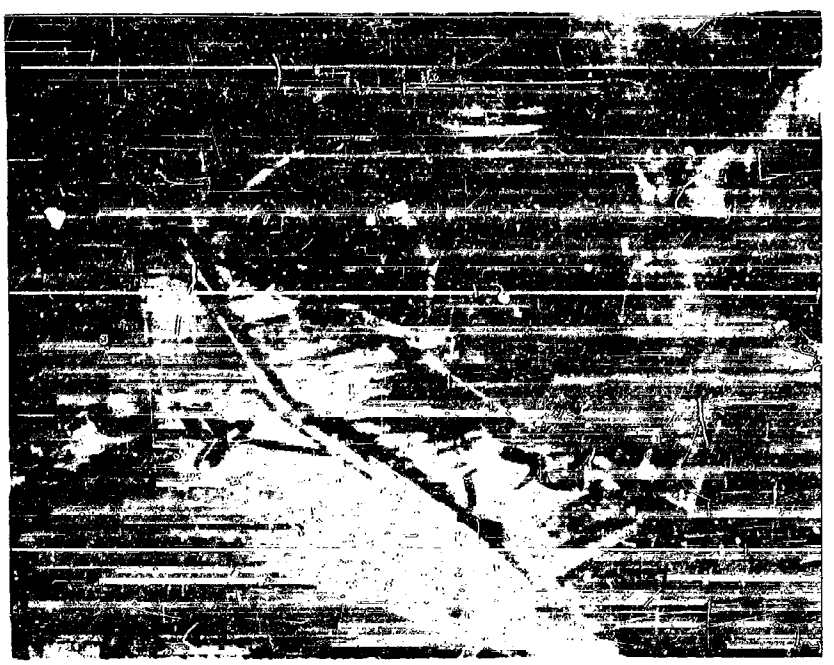


GASOLINE TANK - HEI

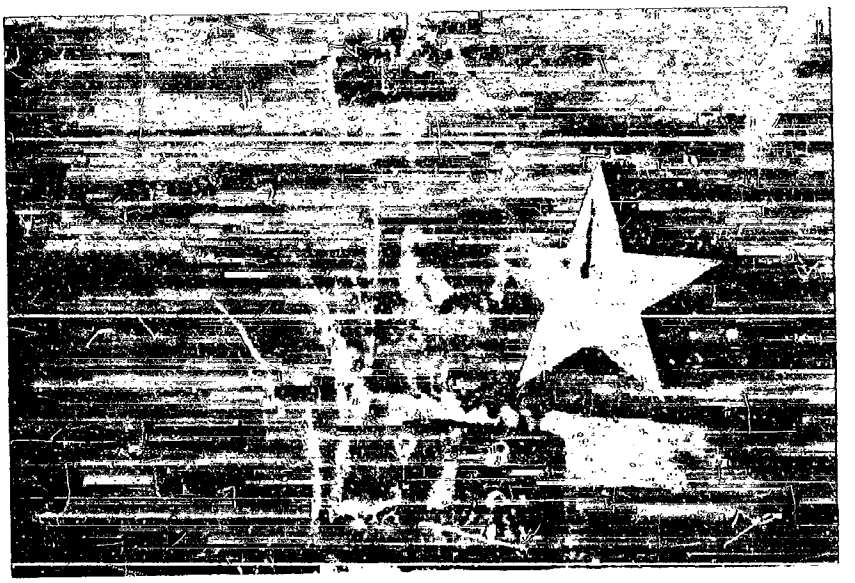
TRUCK FRAME - HEI

HOOD - HEI

ENGINE - HEI

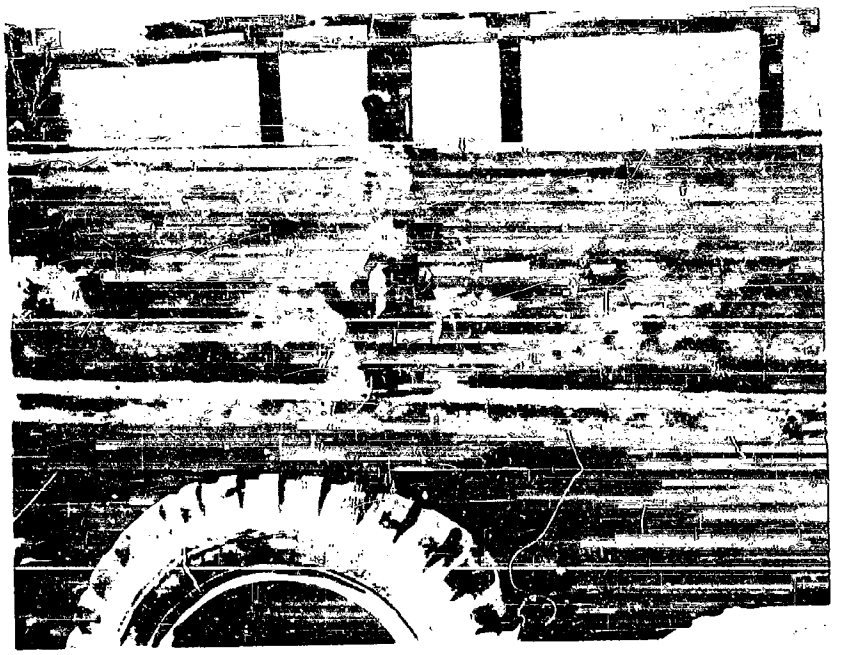


ENGINE - HEI



CAB PANEL - HEI

BODY - HEI

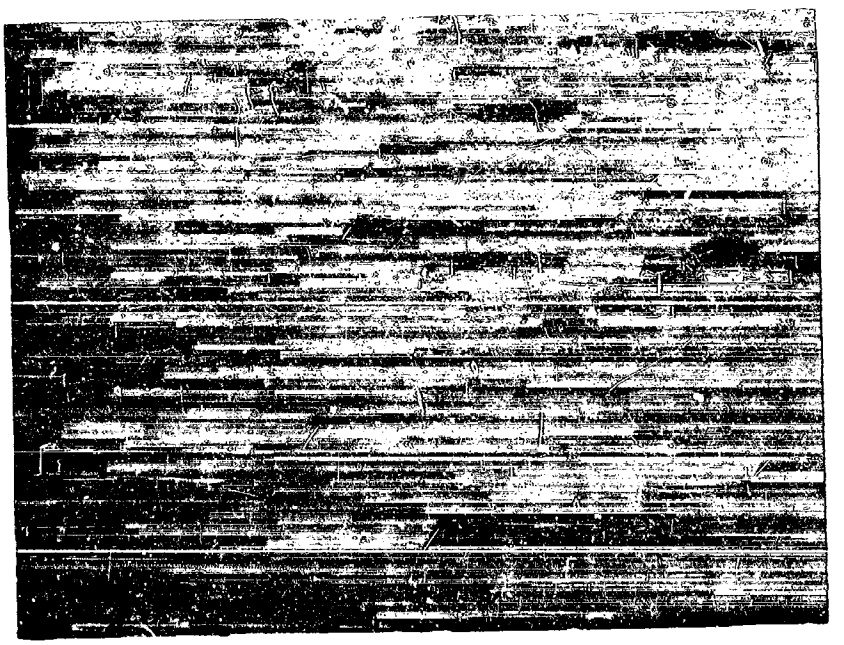


LEFT SIDE OF TRUCK BED - API & HEI

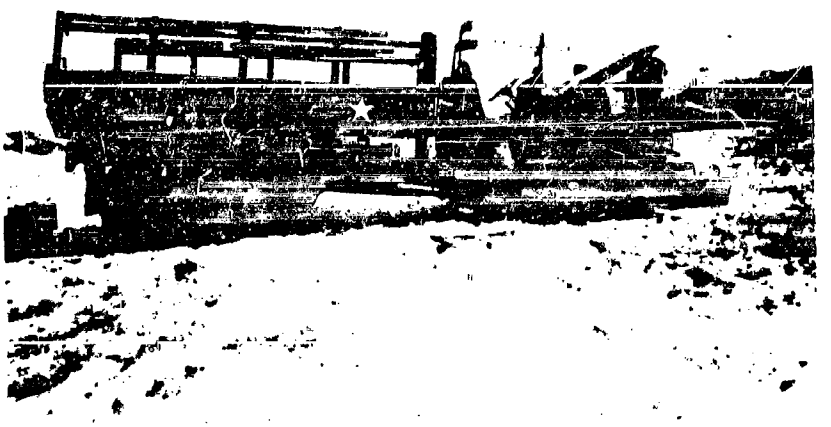
2½ TON TRUCK AFTER ATTACK - API & HEI

TRUCK BED & CAB - API & HEI

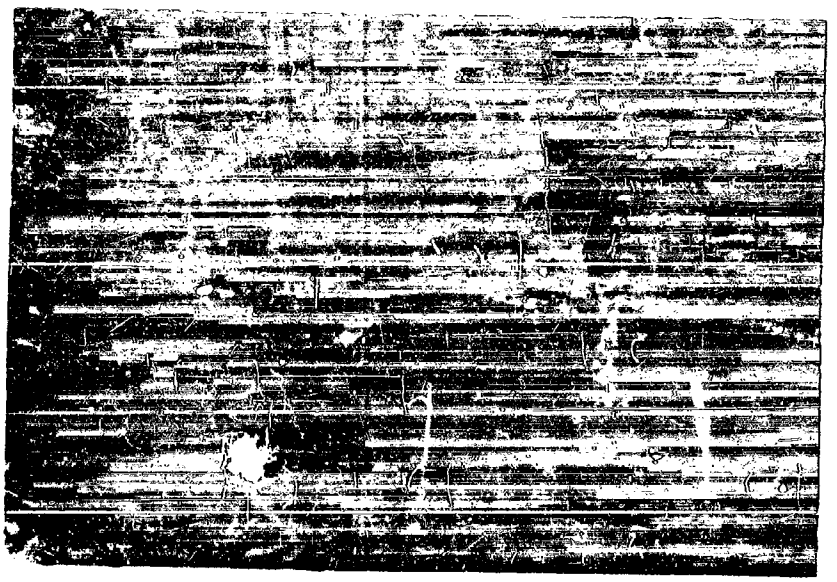
TRUCK CAB - API & HEI



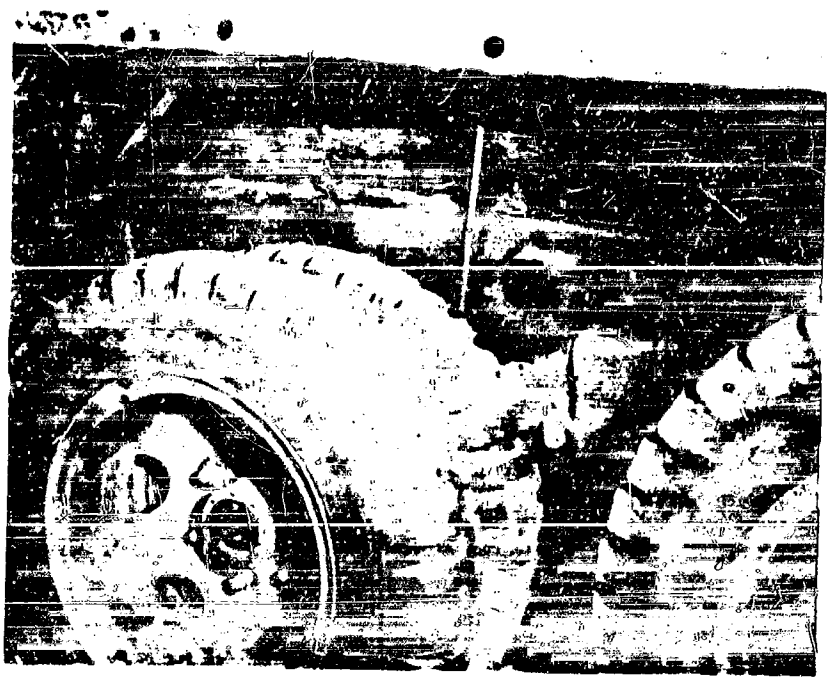
API STRIKE ON SPRING



2½ TON TRUCK AFTER ATTACK - API & HEI

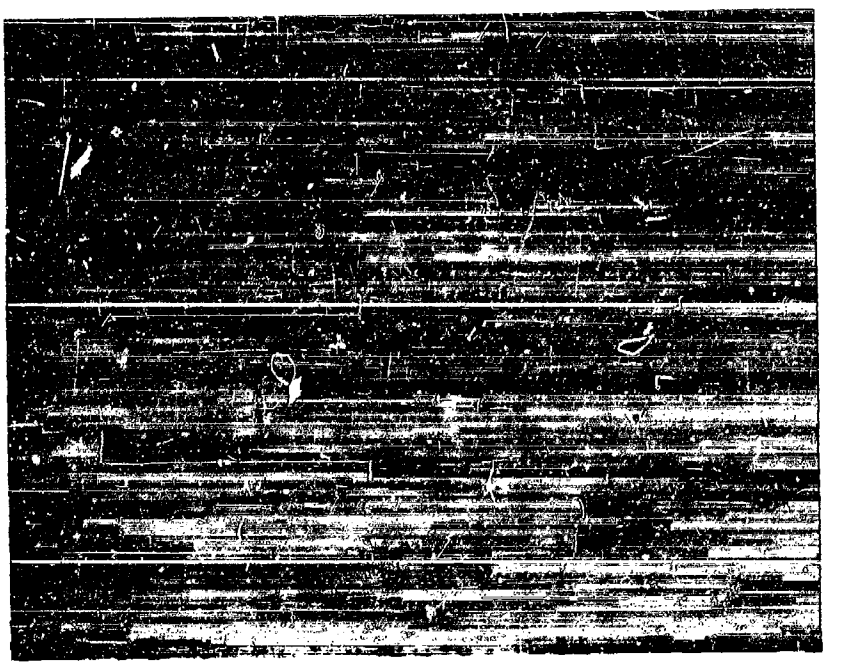


UNDER RIGHT FRONT FENDER - API & HEI

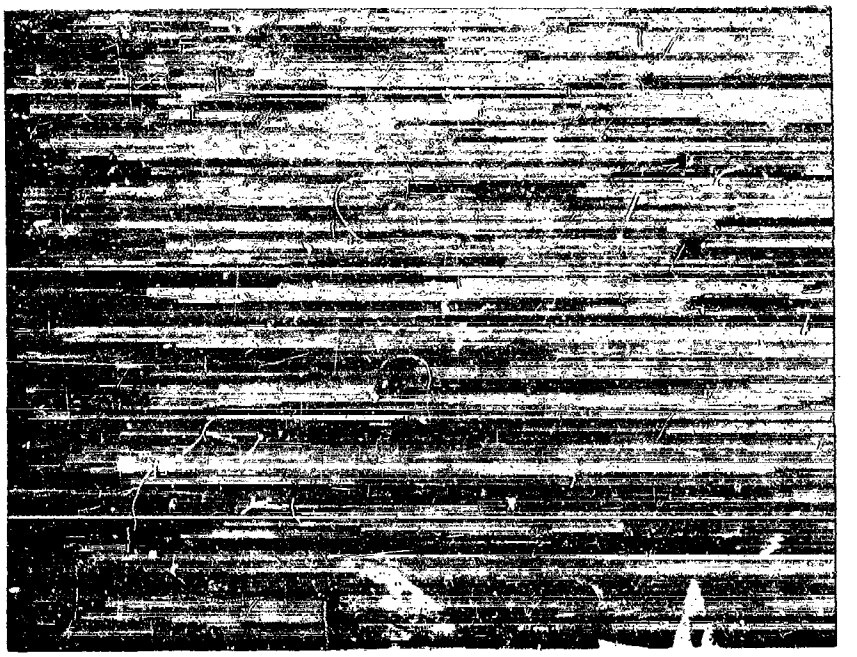


REAR FRAME - API & HEI

REAR OF TRUCK - API & HEI



2½ TON TRUCK AFTER ATTACK - API & HEI



CAB & WINDSHIELD - API & HEI

APPENDIX D

PART IV

PHOTOGRAPHS

OF

EFFECTIVENESS OF API & HEI AMMUNITION

AGAINST TANKS

TANK AFTER ATTACK-API & HEI

API & HEI HITS ON TANK TURRET

API STRIKE ON TANK TURRET

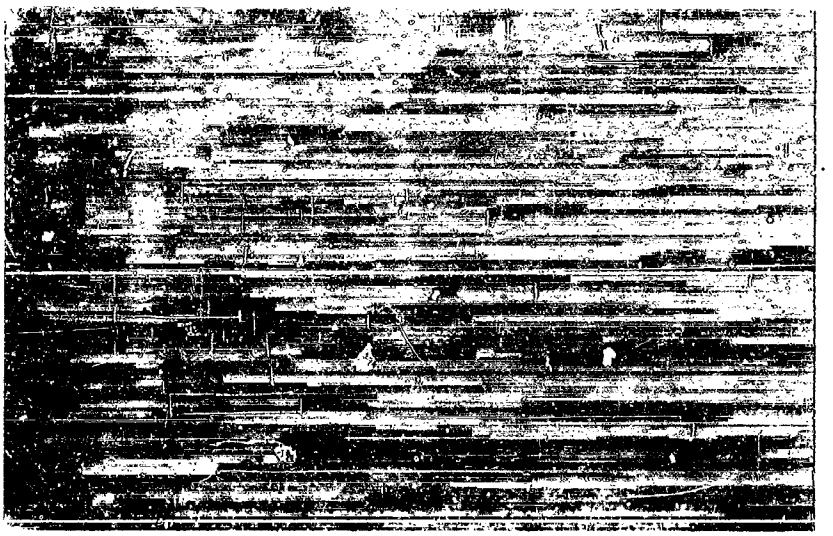
API STRIKE ON INTERCOM JUNCTION BOX - ¼" STEEL

API STRIKE ON TANK BOGEY WHEEL

API STRIKE ON BOGEY WHEEL

HEI STRIKE ON TANK COMPARTMENT

API FRAGMENTS



HEI FRAGMENTS

APPENDIX D

PART V

PHOTOGRAPHS

OF

DAMAGE SUSTAINED TO F-86 TYPE AIRCRAFT

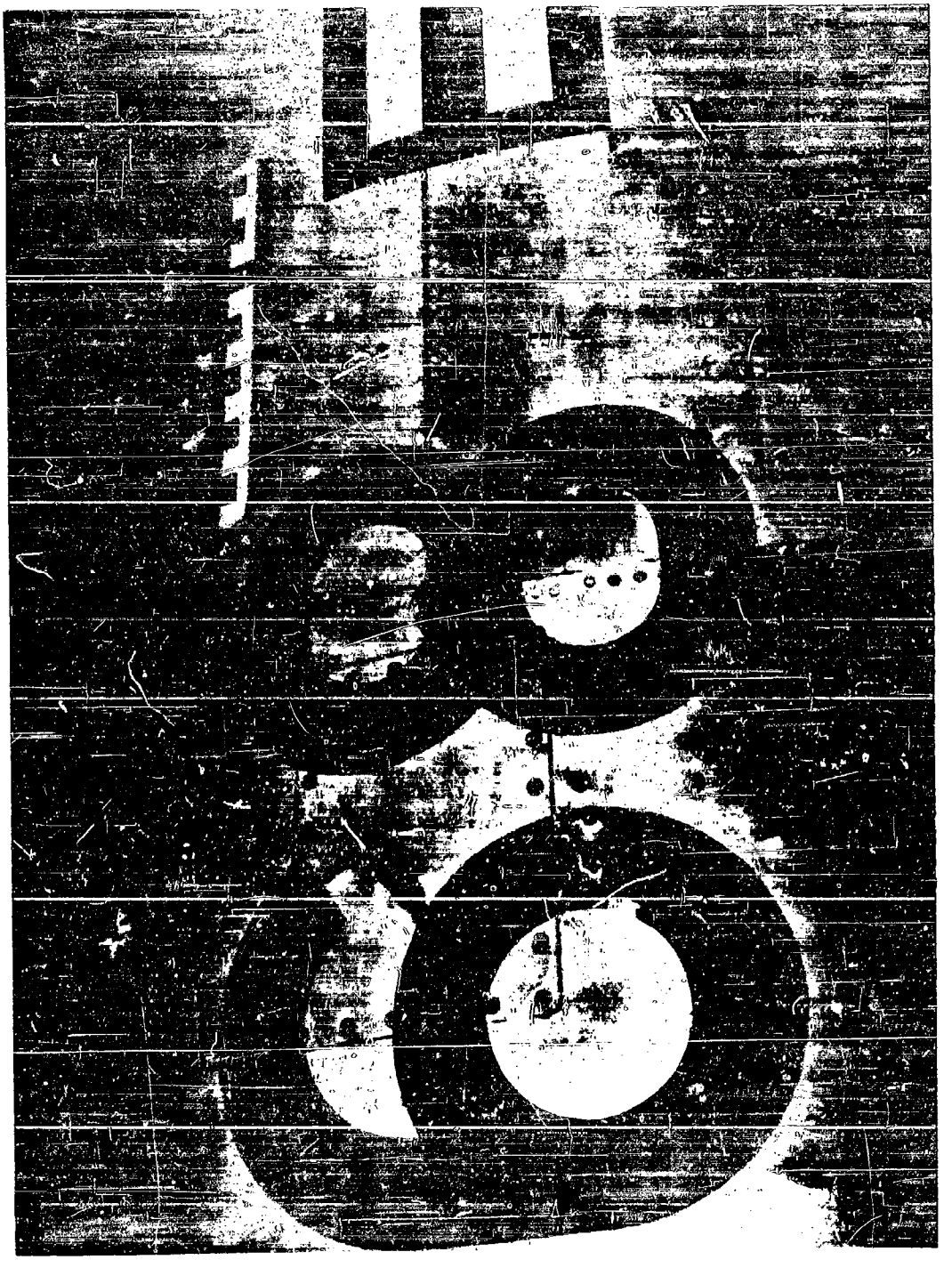
BY ENEMY HE AMMUNITION

BATTLE DAMAGE TO AIRCRAFT #868 FROM 37 MM AND 23 MM ROUNDS FIRED FROM MIG-15 AIRCRAFT

LEFT SIDE OF AIRCRAFT

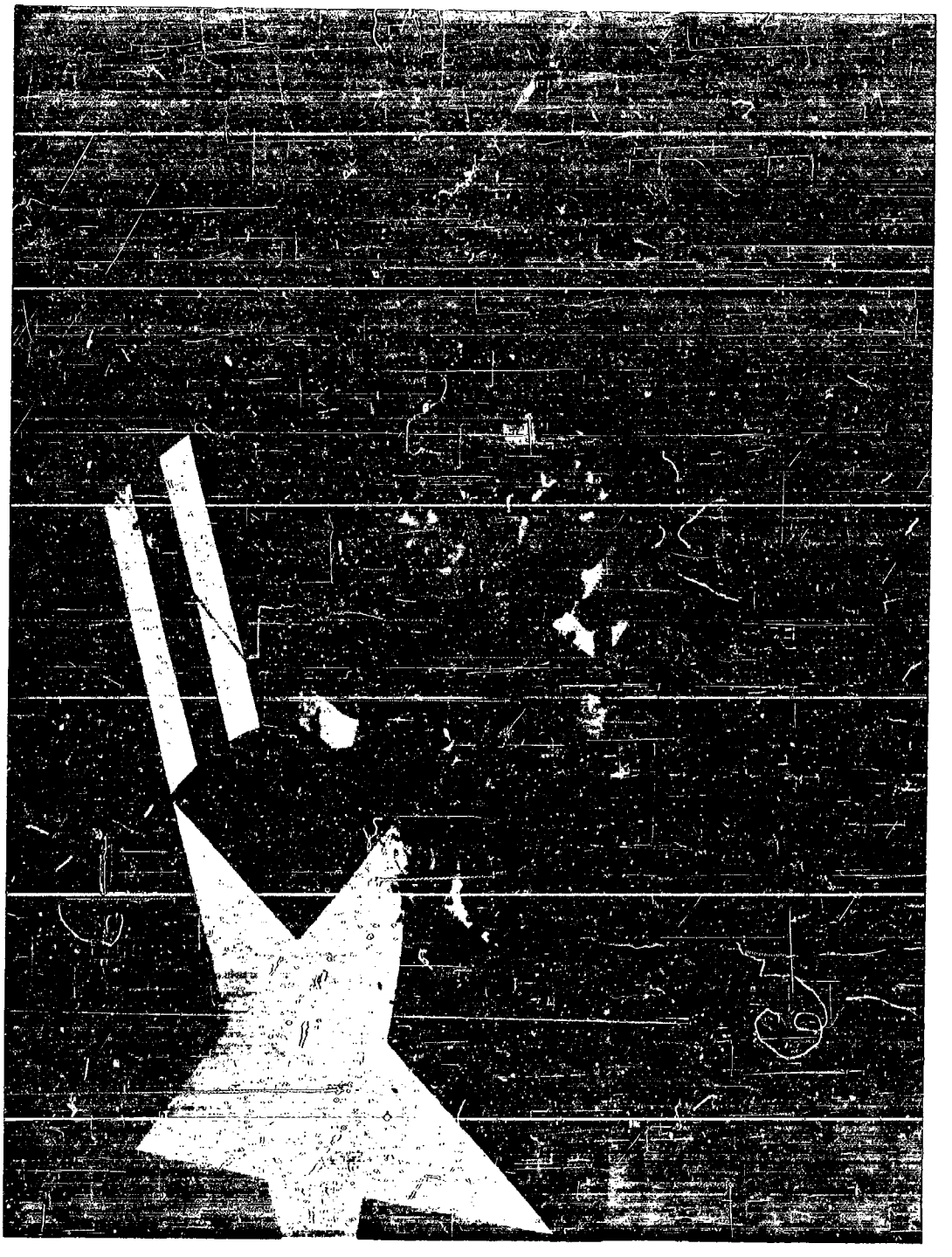
STRIKE OF 37 MM ROUND UNDER TAIL SECTION

STRIKE OF 23 MM IN BOTTOM OF RIGHT WING



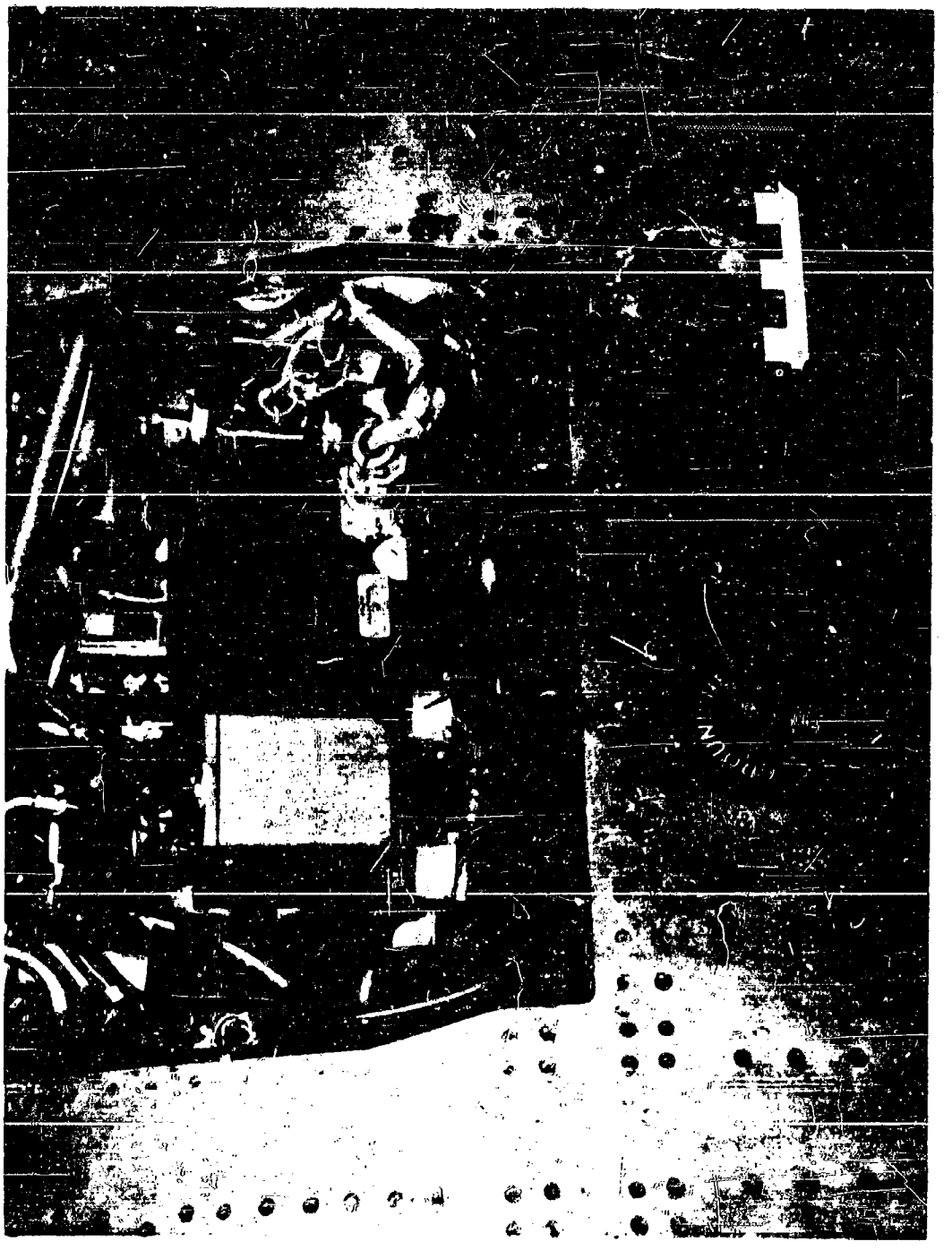
RIGHT SIDE OF AIRCRAFT

DAMAGE TO EXHAUST CONE

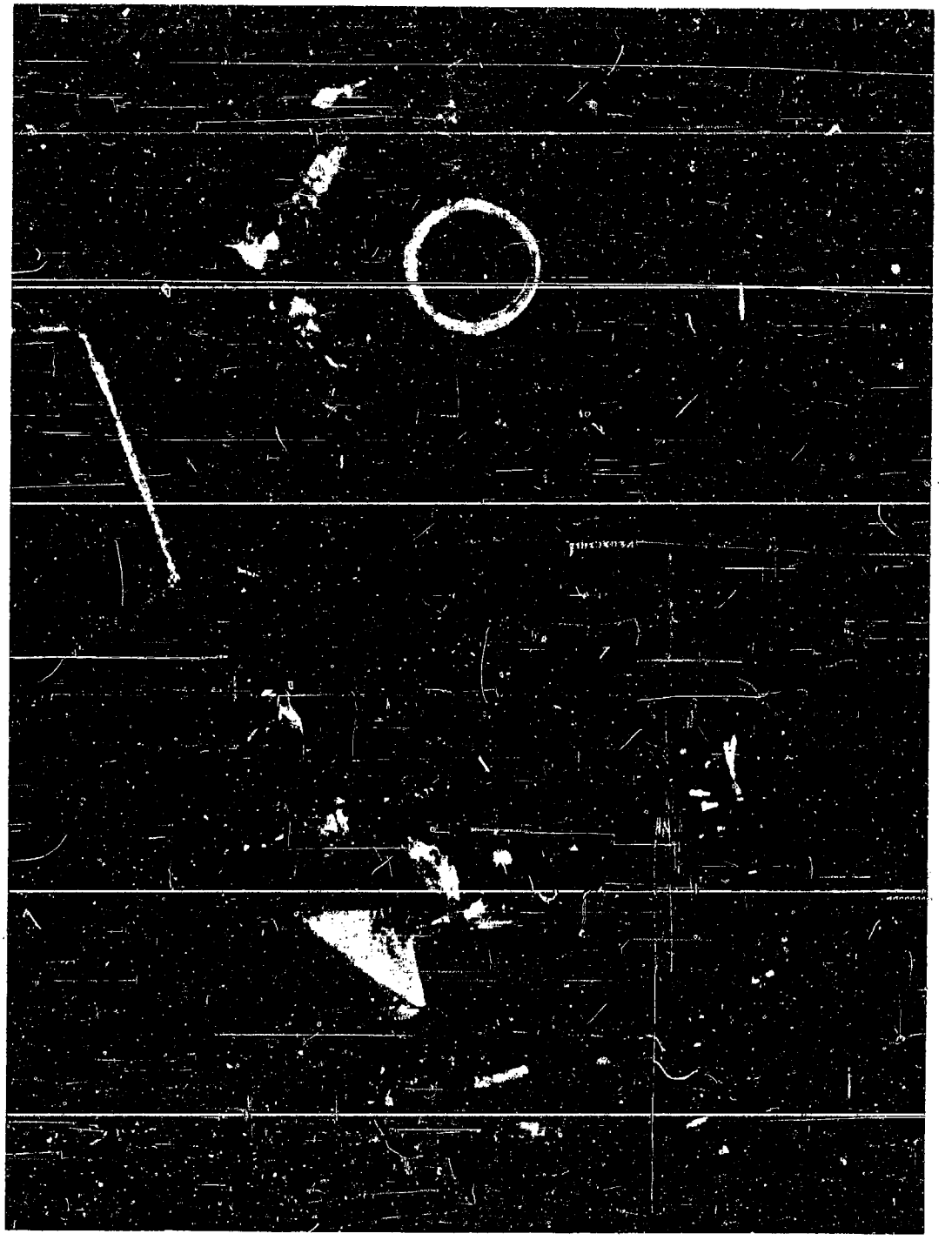


VIEW OF TOP OF RIGHT WING

BATTLE DAMAGE TO AIRCRAFT #836 BY 37 MM HE ROUND
FIRED FROM MIG-15 AIRCRAFT



ENTRANCE OF ROUND RIGHT SIDE OF FUSELAGE

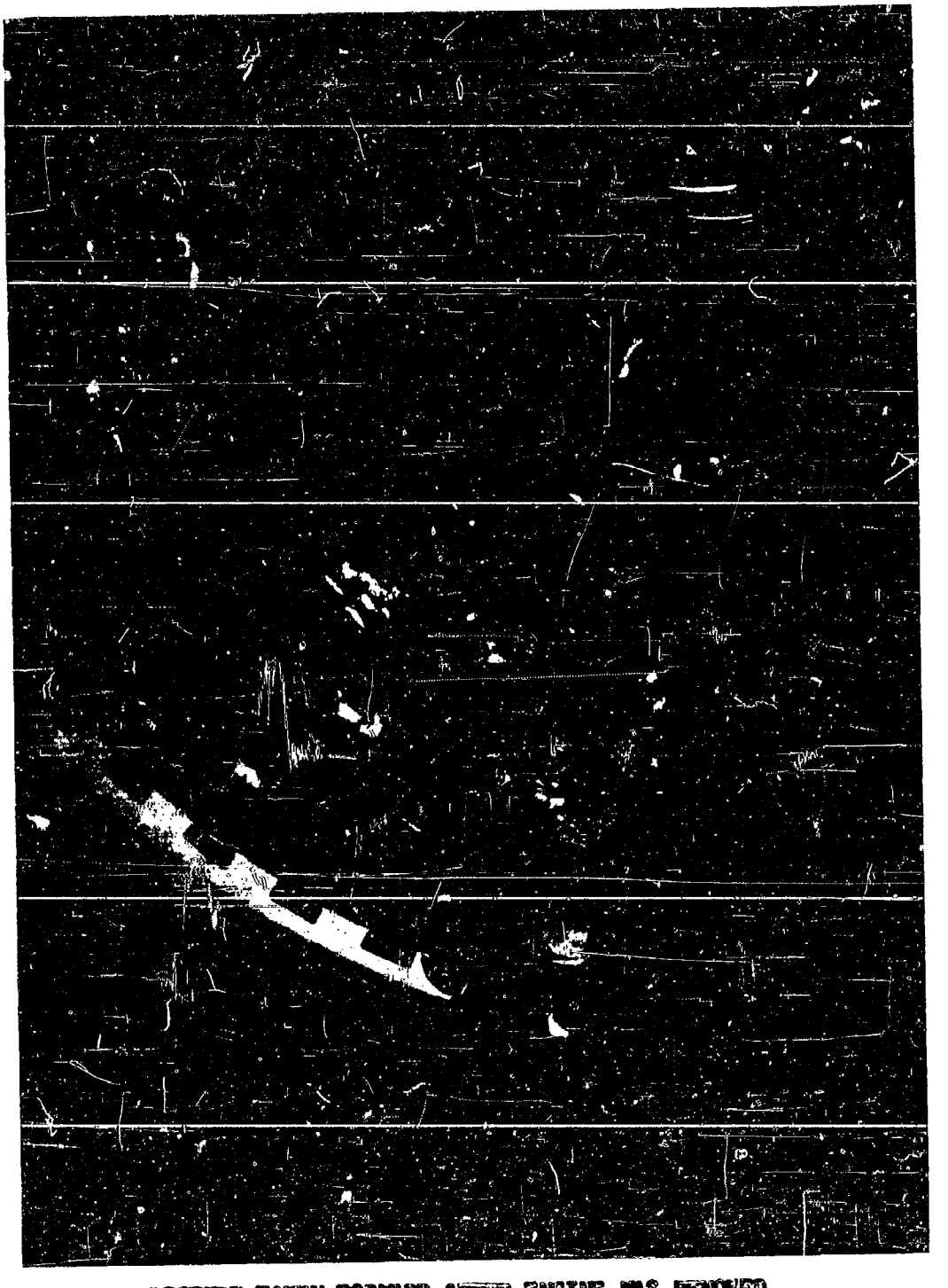


REAR VIEW OF FORWARD FUSELAGE SHOWING DAMAGE INSIDE AIR INTAKE DUCT

LEFT SIDE OF FUSELAGE

AIR INTAKE

COMPRESSOR DAMAGE



PICTURE TAKEN FORWARD AFTER ENGINE WAS REMOVED

APPENDIX E

ARMAMENT RELIABILITY AND MAINTENANCE

1. Introduction

This report covers the period of January 18, 1953 through May 1, 1953 of aerial firing conducted at K-14, Korea. Listed below is the final summary of missions flown and reliability achieved during the test:

January 10th - May 1st	Stoppage Causes
Loaded - 108,393 RDS	Gun - 75 ea
Fired - 98,135 RDS	Instl - 69 ea
Lost - 10,758 RDS	Pers - 20 ea
Fireout - 90%	Ammo - 7 ea
Stoppages - 210	Link - 11 ea
Stoppage Rate - 2.2/1000	Unknown - 28 ea
Missions - 363	

Included as Inclosure #1 is a monthly summary of reliability achieved. This summary indicates the progressive improvement of the armament reliability. Also included as Inclosure #2 is the armament performance record of individual aircraft.

2. Armament Reliability

a. Gun

(1) Of the total of 210 stoppages 75 were caused by "gun" malfunctions. These stoppages were 35.7% of the total stoppages. The malfunctions which were credited to the gun were as follows:

(a) Broken or shorted firing harness 11

(b) Open circuit at ADF (anti-double-feed) contacts 10

(c)	Shorted firing pin assembly	10
(d)	Broken drawbar or firing pin	6
(e)	Firing pin set back in insulation	7
(f)	Broken ADF (anti-double-feed) spring	5
(g)	Ejection failure due to case chute	3
(h)	Rammer missed round	3
(i)	Barrel orifice failure	2
(j)	Broken switch tongue	2
(k)	Round retainer failure	3
(l)	Feeder shaft disengaged	3
(m)	Failure to extrack-unk	2
(n)	Stubbed round against drum	1
(o)	Broken cam insert	1
(p)	Bent link ear guide-feeder	1
(q)	Broken drum shaft	2
(r)	Gauled drum shaft	2
(s)	Broken switch cam	1

(2) The first six malfunctions, all concerned with the gun firing circuit, contributed 65.3% of the total gun stoppages. The remaining 13 malfunctions were 34.7% of the gun stoppages. Based on the above data the most unreliable portion of the gun was the firing circuit. The test brought out the following major deficiencies:

(a) Firing harness: The firing harness proved unsatisfactory, electrically and strength-wise. Sixty-nine harnesses were broken either during firing or in disassembly and assembly. In numerous cases a check of the harness after one

firing mission showed it to be either broken or shorted. It proved difficult to assemble or disassemble a firing harness without bending the harness and possibly breaking it. The five major objections to the present harness are: poor insulation qualities, frequency of open circuits, weak knife blade contacts, poor fit (making it difficult to install or remove), and weak overall construction. (See photo #12, Inclosure #9)

(b) Anvil assembly: The anvil assembly was proven to be the weakest part of the gun firing circuit. Despite the daily cleaning and inspection, (discussed under gun maintenance) the anvil had the following deficiencies:

1. Broken drawbars: 69 drawbars were broken during firing. In a few cases, these caused stoppages; but this was true only because the anvil was inspected and repaired after each firing mission. (See photos #15 & #16, Inclosure #9)

2. Broken drawbar spanner nut insulation bushing: Approximately 110 of these bushings were broken during firing or handling. Here again the stoppages were few only because of a strict policy of inspection and repair.

3. Anvil: 71 anvils were replaced as unserviceable due to either breakage or insulation failure. The major deficiency in the anvil body itself was its poor electrical qualities. The firing pin insulation became saturated with carbon, brass particles, and moisture during and after firing to such an extent that the firing pin was often shorted to ground. This condition occurred even with daily replacement and cleaning. An electrical check was required before each mission to insure a good circuit. A second malfunction caused to some degree by the type of insulation was the sticking of the firing pin in the rear position. Seven of these stoppages occurred during the test. (See photo #11, Inclosure #9)

(c) ADF circuit: 15 stoppages were caused by a malfunction in the ADF circuit. The major difficulty was the problem of obtaining proper contact between the ADF and the contacts on the firing harness. This is a particularly difficult malfunction to detect, and is peculiar to this type switch. Constant opening and closing of the ADF switch causes wear on the male contact and bending of the female contacts. Extremely careful fitting was required to maintain a good circuit. Four ADF springs were broken during firing but this could have been prevented if sufficient spare springs (of the latest type) had been available to permit adequate preventive maintenance. (See photo #7, Inclosure #1L)

(d) Other gun stoppages: The remaining 13 types of stoppages were not considered as serious; however, four other assemblies of the gun besides the firing circuit deserve special mention. These are: the drum shaft and latch, barrels, recoil springs, and drum seals.

1. Drum shaft: Two types of malfunctions were consistently found in the drum shaft. First, the edge of the locking slot in the drum shaft upset during firing. This made the shaft difficult to remove, and it is felt in some cases it hindered the smooth action of the gun. Although this is an undesirable method of maintenance, frequent filing down of the edge was necessary to maintain high gun reliability. Second, the shaft has a tendency to gaul in the bearing surfaces of the drum cradle. In one instance this caused a gun stoppage and only frequent polishing prevented more stoppages.

2. Gas seals: A total of 47 seals were broken during the firing tests. In all but a few cases no damage was done to the face of the barrel, but it can be assumed that abnormal amounts of gun gas must have been forced into the gun bay. This is a serious problem since the purging system was marginal in previous tests under these conditions. One particularly interesting fact was noted about seal breakage.

During the first 6 weeks of firing when the ground temperature was at its lowest (5° F), 36 seals were broken. In the next 7 weeks when the temperature had risen considerably only 11 seals were cracked. In both periods approximately the same number of rounds were fired and the seals looked identical in all respects. (see photo #10, Inclosure #9)

3. Recoil springs: Forty-four recoil springs were either broken during firing or were broken upon receipt. Twenty-two of the 44 were broken when the guns were uncrated for initial installation. The remaining 22 were broken during the firing test. The life of the new springs was approximately 108 rounds (proof firing by manufacturer) while the ones that broke after firing had a life ranging from 1000 to 3000 rounds. No stoppages could be directly attributed to the recoil springs, but in several cases it was felt they were a contributing cause to a decrease in cyclic rate and broken slideway welds. (See photo #7, Inclosure #9)

4. Barrels: Although the barrels only caused two stoppages, they are considered unsatisfactory. The average barrel life was found to be 330 rounds. The chief deficiency was the failure of the barrel orifice to last the full life of the barrel. Orifices cracked and/or turned after as few as 10 rounds. Two stoppages were caused when the orifices completely disintegrated and stopped the guns. More of this type stoppage was prevented by the inspection of the orifice after each firing mission. Of a sample of 212 barrels, 156 were retired before the end of their normal life due to either a cracked or turned orifice. Barrel life data indicated that the failure of the orifices cut the barrel life in approximately one half. Approximately 6 barrels had damaged faces, but in all cases, this was due to a cracked seal. Some barrels were encountered that would not fit either the gun or in some cases, the

barrel stabilizer. This seemed to indicate a lack of quality control in the manufacture of the barrels. (See photos #8 & #9, Inclosure #9)

(3) Included in this appendix are the following: gun reliability chart, Inclosure #1, showing individual stoppage rates for each gun used during test; photographs of breakages most commonly encountered, Inclosure #9; and, a sample of barrel life based on 100 barrels, Inclosure #6.

b. Installation:

(1) Of a total of 210 stoppages during firing, 69 were caused by an "installation" malfunction. These 69 malfunctions were 32.9% of the total stoppages. The malfunctions which were credited to the installation are as follows:

(a)	Link container volume insufficient	29
(b)	Link chute	24
(c)	Electrical firing system	10
(d)	Charger	5
(e)	Case Chute	1

(2) Based on the above data, the link chutes and link containers were the most unreliable parts of the installation. Link troubles caused 76.8% of the installation malfunctions. Following are the major deficiencies:

(a) Link Chutes

1. The joint between the link chute and the feeder was misaligned and subject to movement. At the start of the Korean test, a modified chute was used. The design of the chute itself was an improvement over the original link chutes, however, the chutes were not properly fitted to the feeder. This problem was eliminated by replacing the modified chutes with the original link chutes. Occasional jams still occurred at

the feeder exit, but they were much less frequent than with the modified chute. (See photo #4, Inclosure #12)

2. The original link chutes are subject to jams in the chute due to the design of the guiding surfaces.

3. The volume of the link container for the upper guns in particular was insufficient and caused the links to back up and jam in the chute.

(3) In view of these difficulties, the link chutes were removed from the upper guns entirely. The links were free to drop in the gun bay proper. To prevent a link from jamming either gun, the space was properly baffled with ordinary window screen. The screen baffles worked satisfactorily, and no stoppages were caused. (See photo #1, Inclosure #12)

In order to improve the link disposal system for the two lower guns, a hopper was installed in one aircraft. It consisted of a sheet metal tray that guided the links into the rear link compartment without aid of a chute. This modification was flight tested and performed satisfactorily. (See photo #2, Inclosure #12)

(b) Pneumatic gun charger: Despite efforts to boost the power of the pneumatic gun charger, it has not been effective under the conditions to which it has been subjected. Charges which operate the gun perfectly during ground checks will not successfully cycle the guns at high altitudes. It can only be assumed that extremely low operating temperatures are the contributing factors in charger malfunctions in the combat theater. Gun charger pressure, which was 1100 PSI design pressure, was increased to 1300 PSI. Also, the pneumatic quick disconnect, which was thought to be an air line restriction, was removed and replaced by a straight fitting. In view of continued unsatisfactory operation after these fixes, the gun chargers were removed from the installation, and charging was manually accomplished on the ground. The anti-double charge

switch, which served no function once the chargers were removed, was also removed at this time.

(c) Electrical Firing System:

1. The Cannon Plug: The connection of the aircraft wiring circuit to the guns is rather fragile. Due to the location of the plug with respect to the other equipment in the airplane, it is difficult to install the connector with the gun in place. If the connector is installed on the gun prior to the gun's attachment to the rear mount, the mass of the gun and movement required to mount it cause undue loads to be imposed on the connector.

2. Purge Delay Relay: As originally installed, the purge relay caused a delay in firing short, rapid, intermittent bursts. This was considered unsatisfactory for combat; therefore, the relay was removed from the circuit. Additional purging after completion of each burst, which was the function of the relay, was deemed unnecessary in that previous tests indicated the purging system adequate to perform one burst firing of the full ammunition complement.

3. Electrical System Wiring and Location: Wiring to the cannon plug connector on the gun should be encased in material of a more durable nature. A flexible conduit from the connector to the aircraft structure would be more suitable than the shielded, insulated cabling now used. It would be desirable to simplify the electrical gun firing circuit, especially toward elimination of the many relays now employed, and locating gun firing package in a more accessible compartment.

4. Ammunition Heat System: The ammunition heat system is of questionable value on the present Gun Val ammunition box configuration. Late in the airplane design program, it was found necessary to add an additional tray to prevent delinking of the ammunition from the

links. This tray blocks the flow of heated air to the ammunition boxes and heats only the top layer of ammunition. It is felt that no heat would be better than heating the few rounds of ammunition laying on the ammunition box tray.

5. Purging System: At no time were there any indications that the purging of the gun bay area was inadequate, though guns were fired often under the worst possible condition for purging, (i.e., extreme altitude, low Mach).

c. Stoppages of an Unknown Cause:

(1) Of the total of 210 stoppages only 28 could not be positively attributed to any part of the armament system. These malfunctions were 13.3% of the total stoppages. The different types of "unknown" stoppages were as follows:

(a)	Failure to fire	20
(b)	Failure to eject or extract	4
(c)	Failure to cycle	2
(d)	Failure to return to in-battery	1
(e)	Debulleted round	1

1. Failure to Fire:

By far the most serious "cause unknown" stoppages were the failures to fire. These were 69.3% of the total unknown stoppages. In all 20 cases, the gun was in the in-battery position with a good round in the firing chamber. A thorough check of the electrical firing system indicated no apparent electrical failure; however, all evidence pointed toward some form of electrical trouble. The possible existence of intermittent short or open circuits during in-flight firing conditions seems to be the most reasonable attempt to explain the malfunctions. In no way did the test indicate that electrically primed ammunition is undesirable, but rather it

illustrated the need for a simple, rugged firing circuit.

2. Of the remaining 8 malfunctions, none in themselves were considered serious except the debulleted round. This problem is discussed under the section on ammunition.

a. Ejection Failures:

The four cases of a failure to extract were unexplainable at the time they occurred but a later incident provided the probable cause. Three of the failures to extract occurred on the lower right hand gun of aircraft No. 868. After these three malfunctions, a thorough inspection of the case chuting revealed a partial obstruction in the fixed part of the case chute in the aircraft. The obstruction was ground down and the malfunction did not occur again.

d. Personnel:

(1) Personnel errors resulting in gun stoppages totaled 20 out of the 210 stoppages. These errors amounted to 9.9% of the total stoppages. The different personnel errors encountered were as follows:

(a)	Improper assembly of gun	6
(b)	Improper linking of ammunition	3
(c)	Case chute not connected or improperly connected	2
(d)	Improper charging	2
(e)	Improper inspection	4
(f)	Improper loading or handling of ammunition	1
(g)	Link chute not connected or improperly connected	1
(h)	Barrel latch not properly latched	1

(2) Most of the above errors occurred during the first four weeks of firing. These can be attributed to the inexperience of the armorers who joined the project on a loan basis from the 4th Fighter-Interceptor Group. A strict preflight and postflight check list was prepared and personnel errors were held to a minimum for the remaining period of the test.

e. Links:

(1) Of a total of 210 stoppages, 11 were caused by link malfunctions. These 11 malfunctions caused 5.2% of the total stoppages. The malfunctions encountered were as follows:

(a)	Defective connecting ring	6
(b)	Broken or bent ears	5

1. Link Ring:

Considering the total number of links used (approximately 100,000) the 11 cases of defective links was not considered serious. In many instances it was difficult to determine that the rings were actually defective.

2. Link Ears:

This stoppage was also difficult to determine; either the ears were defective or the whipping of the belt against an obstruction in the feed system caused the breakage. Many times links were found with stiffeners missing or loose in the link chutes and containers. Although the loss of the stiffeners was caused by the design of the link chutes, a more secure method of fastening the stiffeners to the link body appears desirable. All links used were T61E2 of lot L8.

f. Ammunition:

(1) Of a total of 210 stoppages during the firing of 98,135 rounds, 7 were caused by ammunition malfunctions. The malfunctions credited to the ammunition were as follows:

(a)	No propellant charge	4
(b)	Oversize case	1
(c)	Undersize case	2

1. No Propellant:

The most serious malfunction was the four cases of a gun stoppage due to rounds with no propellant. After the occurrence of these four incidents all ammunition was inspected for propellant before loading. During this inspection one other round was found with no propellant. Four of the rounds without propellant were from lot No. KOP 47-2. This was HEI ammunition. The fifth round without propellant was found in HEI ammunition lot No. KOP 47-3. In all cases, the rounds appeared normal with the exception of no propellant charge. Since approximately one half of the 98,000 rounds fired was HEI, an average of one round in 9,800 contained no charge. This indicated a serious lack of quality in the ammunition and imposed a considerable inspection burden on the armament personnel. Attached as Inclosure #13 are photographs of the rounds found with no propellant charge.

2. Cases Out-of-Dimension:

The three cases of an out-of-dimension cartridge case caused the gun to stop.

a. In the case of the undersized rounds the firing pin failed to touch the primer and the gun failed to fire.

b. In the case of the oversize case, the drum would not cycle due to the interference between the rear of the case and the drum cradle. Here again a case of poor inspection caused stoppages during air firing. (See photo #22, Inclosure #9)

3. Primers:

There were no cases of defective or shorted

primers throughout the test. The primers of all rounds that failed to fire were checked with an ohmmeter in the shop after propellant had been removed.

4. Debulleted Rounds:

Although debulleting of the ammunition only occurred twice, this is considered to be a serious condition. The debulleting of the projectile was undoubtedly caused by some violent action in the feeding system. The most unusual case occurred when a projectile was rammed into the drum backwards. (See photos #20 & #21, Inclosure #9)

5. Others:

a. One peculiar incident occurred during a firing mission. The gun stopped in the in-battery position with an empty case in the firing chamber. Upon inspection of the gun a curious yellow powder burn was noted on the front of the drum. (See photo #23, Inclosure #9) Unburned powder of a strange yellow color was found scattered through the gun mechanism. A sample of the powder has been saved for analysis. From the position of the powder burn, it appears that the gun started to cycle with the powder still burning. The powder pressure was insufficient, and the gun returned to its original position. The yellow powder is unlike any other seen in this ammunition, and it is felt a further investigation should be made.

b. Premature Bursts:

On 41 occasions pilots observed what appeared to be white incendiary and HEI explosions during a burst, and their observations were substantiated by gun camera film. The flashes were estimated at ranges of 100' to 2000' from the aircraft. In no cases were the aircraft damaged. (See Photos 24, 25, 26, Inclosure #9)

c. Erratic Flight:

Gun camera film revealed several erratic rounds. These were all API rounds with beeswax tips to make a trace. The rounds appeared to veer far off the normal path of the other rounds.

3. Armament Service and Maintenance

a. Gun

It must be realized that this weapon is still in the development stage and some of the difficulties encountered during this test which affected the reliability of the weapon have been, or will have been, eliminated; and that the maintenance burden imposed and preventive maintenance procedures used throughout the test will not necessarily be a requirement for obtaining an acceptable gun performance in future armament installations.

(1) Prior to installing factory received weapons in the aircraft, the following modifications and/or operations were accomplished to insure maximum gun performance during combat operation of the aircraft. (See photographs Inclosure #11)

(a) Cast drum cradles were replaced with forged drum cradles.

(b) Steel gas pistons were replaced with titanium pistons.

(c) Standard type barrel and drum shaft latches were replaced by positive-locking, threaded latches.

(d) Installed latest type extractor spring screws.

(e) Cut access holes in feeder housing to permit attachment of manual charging cables to slide.

(f) Installed filler plates on slide assembly.

(g) Drilled anvil knock out holes in drum cradles.

(h) Installed latest type anti-double-feed springs.

(i) Installed modified link guide tracks with extension.

(j) Modified recoil spring covers, inspected spring elements and reset preload to 1000-1100 pounds.

(k) Checked clearance of drum rollers in cam path and relieved where binding was encountered.

(l) Checked continuity of gun firing circuit.

The rework listed was performed on a total of eighty guns and required approximately 30 man hours per gun.

(2) Upon the installation of the new guns in the aircraft a strict maintenance procedure was adopted and followed throughout the entire program. This included daily preflight and postflight inspections which were performed by the flight line personnel, and the gun overhaul inspections which were performed by the shop personnel.

(a) Preflight Maintenance:

The preflight check required approximately 1½ man hours per aircraft. If an electrical failure is detected in a gun, it requires an additional 30 minutes to change the anvil assembly and/or firing harness. (Reference Inclosure #8 Page 4)

(b) Postflight Maintenance:

The postflight check required approximately 2 man hours per aircraft. Additional postflight time is dependent upon whether or not stoppages occurred. Some stoppages required two man hours to clear; for example, a link jam in the link chute and feeder with the slide out of battery. In other cases, it is necessary to remove the gun from the aircraft to repair it. (Reference Inclosure #8 Page 1 and 2)

(c) Shop Maintenance:

The portion of the maintenance program performed in the shop consisted of pre-installation gun inspection and the intermediate gun inspection which are similar in time involved and procedure used. The intermediate inspection was performed

at the assumed half-life of the gun (1200 to 1500 rounds fired). Approximately 16 man hours were required to remove 4 guns from an aircraft, perform the shop inspection and servicing, and re-install the guns. (Reference Inclosure #8 Page 3 and 4)

(d) Additional SOP's:

As a result of gun maintenance experience gained prior to, and during the first weeks of this test, three other shop maintenance procedures were set up and followed throughout the remainder of the program. (Reference Inclosure #8 Pages 2, 3 and 4)

(e) Additional Gun Maintenance Procedures:

It was deemed advisable to change anvil assembly daily, due to the high percentage failing to meet the electrical check prescribed in the shop SOP's and preflight and postflight checks. If a harness assembly also failed to pass the preflight check or postflight check, it was removed to the shop and checked in the following manner:

A meg meter is applied using 500 volt DC, and if there is no leakage indicated, the harness is suitable for use at altitude conditions. The change in electrical characteristics of the firing circuit at altitude made necessary the 500 volt check at sea level. Limited to the use of a 1½ volt ohmmeter at sea level one does not often detect a leakage that occurs with the aircraft 400 volt circuit at altitude. Also using the meg meter (500 volt capacity) it was possible to detect insulation failures in the anvil assembly. All of the above mentioned maintenance procedures and SOP's were the results of the combined experience of all the team personnel participating in this program. They were considered absolutely essential to obtain the maximum efficiency from the model gun used in this test.

(f) Personnel and Training Requirements:

Because of the increased weight of the gun and

the numerous other deficiencies discussed in this report, the maintenance burden was approximately 50% greater than that of the normal .50 caliber gun installation. During the first 8 weeks of the test, 2 armorers were required to service each aircraft. In the later weeks, two men working as a team serviced two aircraft. Experience gained during the test indicates one man can perform the normal preflight and postflight; however, any abnormal incident requires two men. Shop maintenance was considerably greater, and several men were kept busy at all times in the armament shop. It was the consensus of most armorers that assembly and disassembly of the revolver type weapon were easily performed, although six of the personnel errors were due to improper assembly of the gun. In most cases these could have been avoided with either more training or preferably a redesign of the parts to prevent malassembly. A typical illustration of this is the gas tube adaptor, which if improperly assembled, causes the gun to stop after firing one round. A simple redesign could eliminate this type error.

In general, the problems of the T-160 gun with its electrical firing circuit are more difficult than the problems associated with the .50 caliber gun installations. Due to the numerous electrical difficulties found in both the gun and the aircraft firing circuit, it is felt that a better understanding of basic electricity is desirable for the armorer who is to be trained to service this weapon.

b. Installation Maintenance

There are several deficiencies existing in the present installation that affect the servicing and maintenance of the gun installation.

(1) Setting up and firing in of guns on the Boresight Range constitutes the major problem from the standpoint of time involved and difficulty in accomplishing the desired results. For complete details, refer to Appendix C, "Boresighting and Harmonization".

(2) The complexity and poor accessibility of the firing circuitry requires excessive maintenance time in locating and correcting electrical troubles.

(3) The air compressor system which operates the purge doors and gun chargers requires special maintenance daily during the winter months of operation, such as thawing compressors and actuating pneumatic purge doors to insure their operating satisfactorily prior to take-off.

(4) Cleaning of gun bays and blast panels imposed additional maintenance upon flight line personnel. Because of inherent gas leakage characteristic of this type weapon, excessive deposits of carbon accumulated throughout gun bay areas and associated equipment in the gun bays. It would be desirable for future installations to have removable pans or baffles located beneath the guns to ease this maintenance burden.

(5) Link chutes were difficult to remove when link jams occurred during firing. An excessive number of man hours was spent in clearing this type jam. As a result the upper link chutes were removed and the links contained in the gun bay area with appropriate screening. It is believed that hopper type link containers instead of chutes would be advantageous from a servicing standpoint.

(6) The ammunition loading cycle is approximately the same as the .50 caliber installation and the added maintenance is negligible.

Monthly Summary of Aerial Firing and Reliability

18 Jan 1953 - 20 Feb 1953

Loaded - 38,462 RDS
Fired - 32,446 RDS
Lost - 6,026 RDS
Fireout - 84.4%
Stoppages - 111
Stoppage Rate - 3.42/1000
Missions - 100

Stoppage Causes

Gun - 27 ea
Install - 54 ea
Pers - 13 ea
Ammo - 3 ea
Link - 3 ea
Unknown - 11 ea

21 Feb 1953 - 21 Mar 1953

Loaded - 25,484 RDS
Fired - 23,524 RDS
Lost - 1,960 RDS
Fireout - 92.3%
Stoppages - 42
Stoppage Rate - 1.8/1000
Missions - 110

Stoppage Causes

Gun - 24 ea
Install - 3 ea
Pers - 4 ea
Ammo - 2 ea
Link - 1 ea
Unknown - 8 ea

22 Mar 1953 - 17 Apr 1953

Loaded - 30,769 RDS
Fired - 28,791 RDS
Lost - 1,978 RDS
Fireout - 93.4%
Stoppages - 41

Stoppage Causes

Gun - 19 ea
Install - 8 ea
Pers - 0 ea
Ammo - 1 ea
Link - 5 ea

22 Mar 1953 - 17 Apr 1953 (Cont'd)

Stoppage Rate - 1.4/1000

Missions - 115

Stoppage Causes

Unknown - 8 ea

18 Apr 1953 - 1 May 1953

Loaded - 14,168 RDS

Fired - 13,374 RDS

Lost - 784 RDS

Fireout - 94.3%

Stoppages - 16

Stoppage Rate - 1.2/1000

Missions - 37

Stoppage Causes

Gun - 5 ea

Install - 4 ea

Pers - 3 ea

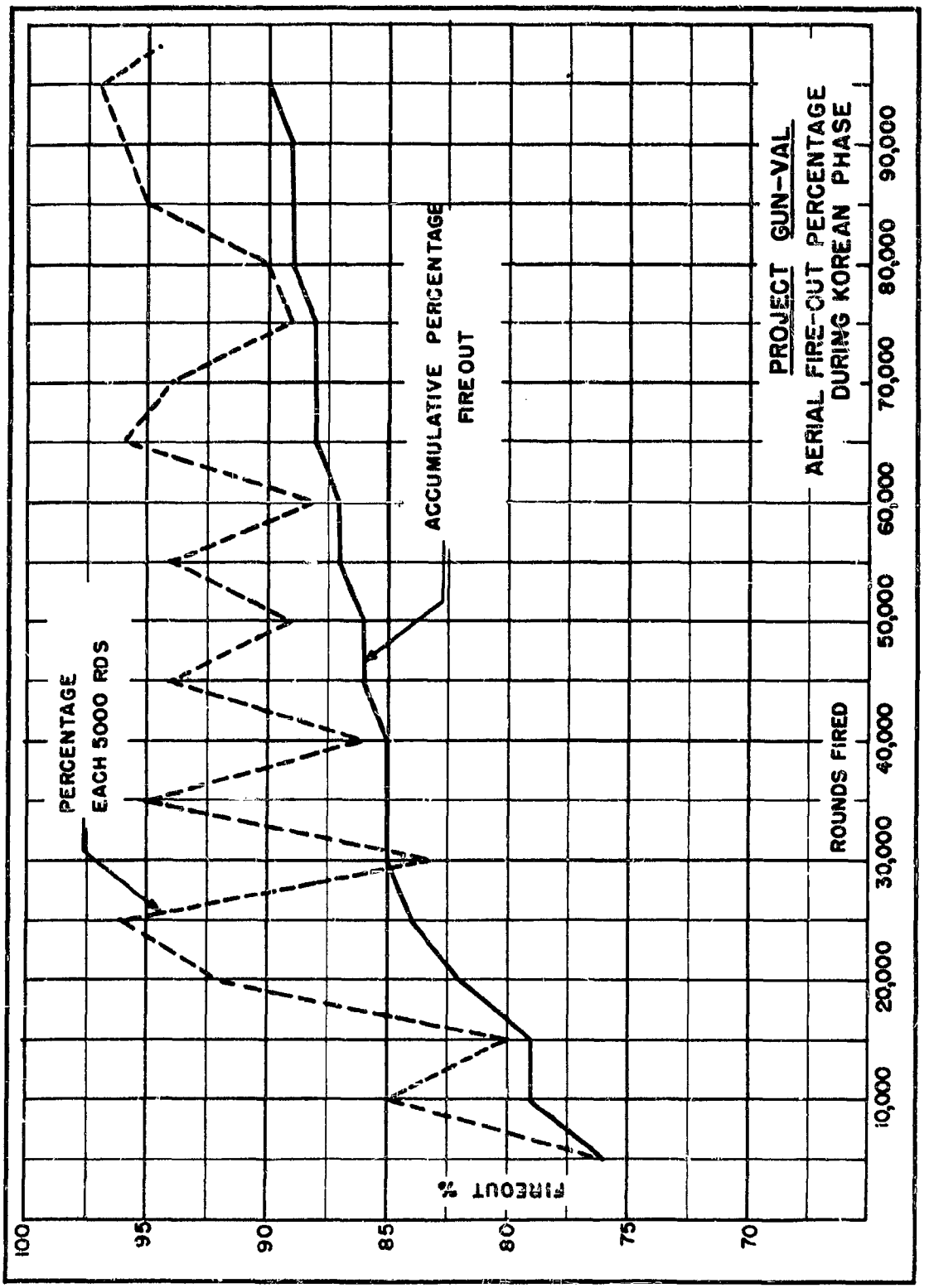
Ammo - 1 ea

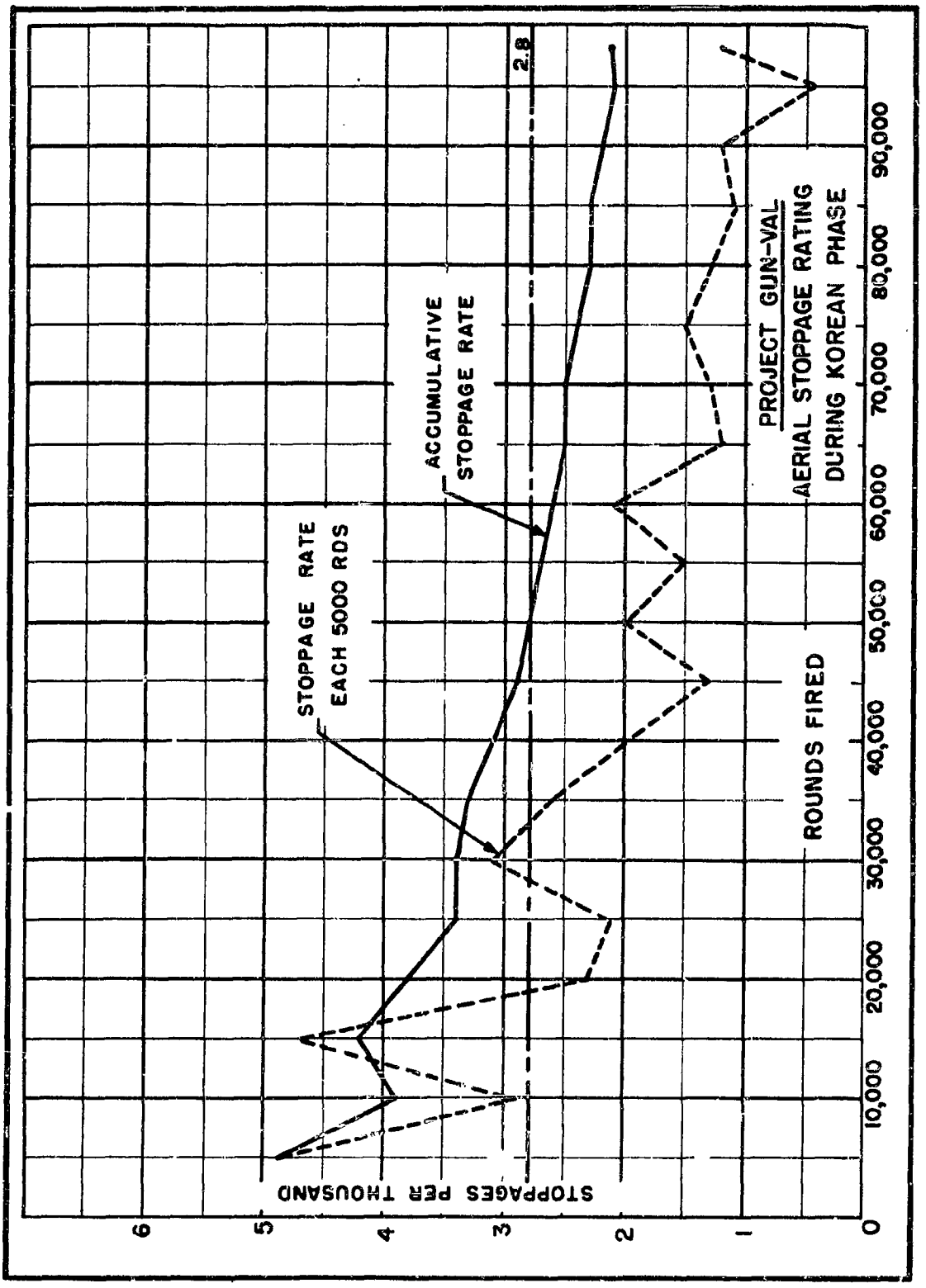
Link - 2 ea

Unknown - 1 ea

ARMAMENT RELIABILITY BY AIRCRAFT

ACFT. NO.	NO. OF MISSIONS	RDS. LOADED	RDS. FIRED	FIREOUT	STOPPAGE RATE	COMMENTS
803	56	15,233	13,865	91%	1.6/1000	Acft lost as result of engine trouble on last day of program.
819	55	16,322	14,464	88.7%	2.1/1000	
826	51	16,300	15,307	94%	1.6/1000	Acft damaged by MIG gun fire on the 4th of April. Did not fly thereafter.
836	32	10,988	10,314	94%	1.5/1000	
855	55	14,366	12,368	86.2%	2.8/1000	
861	3	920	920	100%	0.0/1000	Acft lost 25 January as a result of compressor stall.
867	71	22,327	20,417	90.7%	2.0/1000	
868	40	12,467	10,480	84%	3.7/1000	Acft damaged by MIG gun fire 12 April and did not fly thereafter.

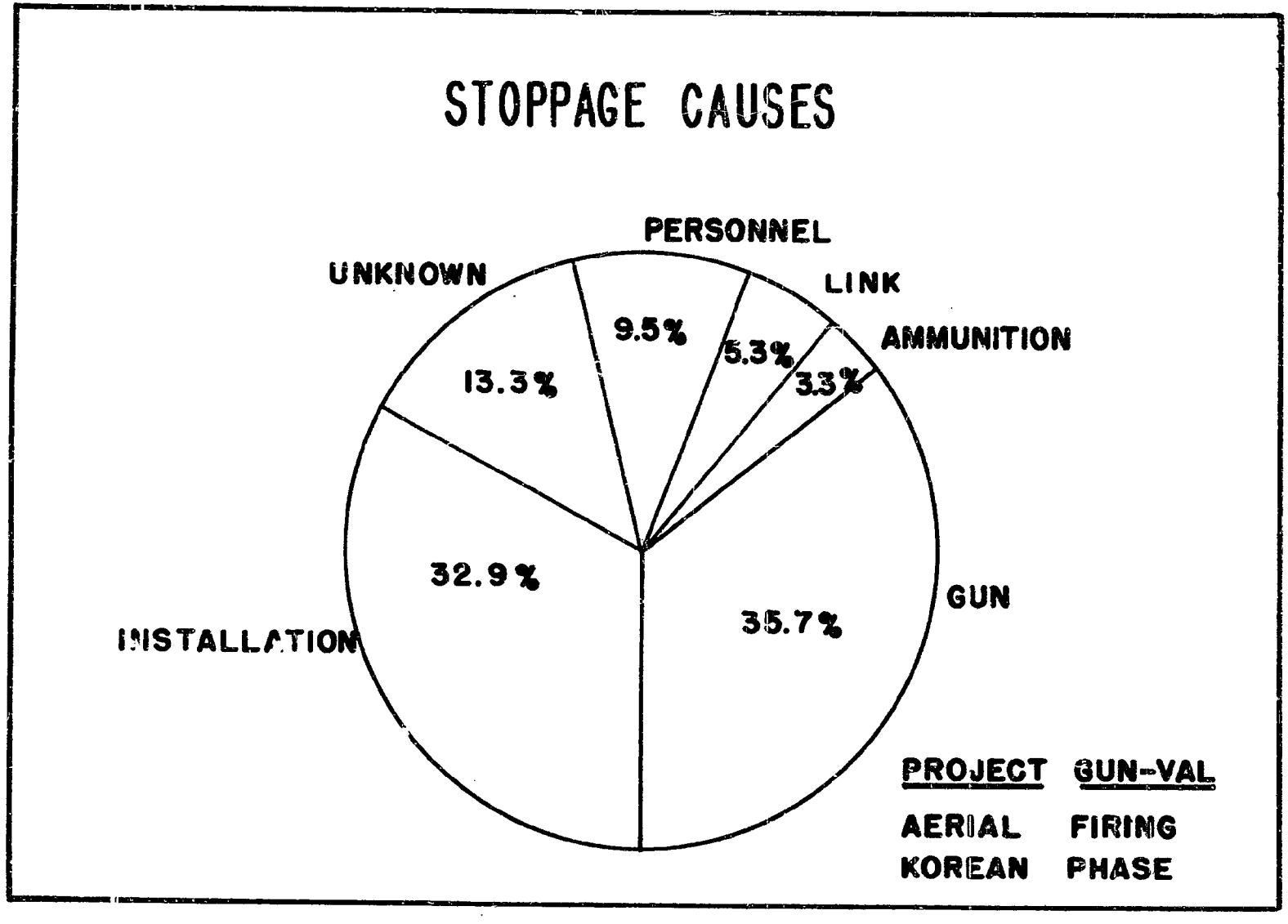

PROJECT GUN-VAL
AERIAL FIRE-OUT PERCENTAGE
DURING KOREAN PHASE
ACCUMULATIVE PERCENTAGE
FIREOUT
PERCENTAGE
EACH 5000 RDS
FIREOUT %
ROUNDS FIRED
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100
95
90
85
80
75
70


PROJECT GUN-VAL
AERIAL STOPPAGE RATING
DURING KOREAN PHASE
ACCUMULATIVE
STOPPAGE RATE
2.8
STOPPAGE RATE
EACH 5000 RDS
STOPPAGES PER THOUSAND
ROUNDS FIRED
0
1
2
3
4
5
6
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000

STOPPAGE CAUSES BY GUN POSITION

18 JAN THRU MAY 1, 1953

GUN POSITION	GUN	INSTALL.	PERS.	AMMO.	LINK	UNKNOWN	TOTAL
UPPER LEFT	19	15	6	3	4	8	55
LOWER LEFT	15	10	6	1	1	10	43
UPPER RIGHT	21	25	4	1	4	3	58
LOWER RIGHT	20	19	4	2	2	7	54
TOTAL	75	69	20	7	11	28	210


STOPPAGE CAUSES
PERSONNEL
UNKNOWN
LINK
AMMUNITION
9.5%
5.3%
3.3%
13.3%
32.9%
35.7%
INSTALLATION
GUN
PROJECT GUN-VAL
AERIAL FIRING
KOREAN PHASE

SAMPLE OF BARREL LIFE

NOTE: All 100 of the mentioned barrels were drilled with new No. 8 drills to bring the orifice size from .187 to .199. One new drill was used on each two barrels. The method of drilling is described in the shop SOP on barrel drilling.

QUANTITY	NUMBER OF RDS. ON BARREL	CRACKED ORIFICE	TURNED ORIFICE	OTHER
16	115	Yes		
12	230	Yes		
5	30	Yes		
5	345	Yes		
16	500	Yes		
4	600	Yes		
13	280	Yes		
2	115		Yes	
2	300		Yes	
1	115			Dam. Face
2	250			Dam. Face
1	550			Dam. Face
2	0			Out of Dem.
17	500			Okay
Total 100				

DAILY TEMPERATURES

DURING PERIOD OF OPERATION

JANUARY 1953	MAX (F) 62 ft	MIN (F) 62 ft	MEAN (F) 62 ft	MIN (F) 41000 ft	MIN (F) 50000 ft
16	21	5	14.8	-60.9	-69.9
17	34	10	24.0	-64.8	-72.4
18	39	22	31.2	-57.0	-68.8
19	34	15	26.7	-59.3	-64.5
20	33	24	29.9	-62.1	-74.0
21	35	16	29.0	-62.3	-73.8
22	39	23	33.5	-58.0	-73.3
23	36	10	29.2	-62.5	-73.8
24	42	20	33.9	-59.6	-76.0
25	35	23	31.5	-67.0	-77.8
26	31	19	26.6	-64.3	-72.9
27	38	14	27.4	-54.0	-71.9
28	32	19	29.0	-53.9	-66.5
29	27	12	21.5	-61.6	-69.3
30	27	7	18.9		
31	26	9	20.0	-60.5	-66.6
FEBRUARY 1953					
1	25	9	19.5	-67.0	-71.5
2	27	5	18.5	-65.2	-78.5
3	32	9	22.5		
4	40	26	33.0	-62.5	-74.9
5	41	19	31.7	-59.3	-77.1
6	32	21	28.1		
7	28	13	22.0	-62.0	-72.4
8	26	9	19.5	-58.0	-70.6
9	34	13	27.5	-70.6	-77.8
10	40	24	34.3		
11	41	31	39.0	-65.7	-77.8
12	41	28	35.0	-76.0	-85.0
13	42	28	35.0	-70.6	-78.3
14	37	24	30.9	-63.4	-73.3
15	29	11	17.6	-67.0	-78.3
16	26	8	19.5	-68.1	-76.0
17	29	16	24.0		
18	30	11	22.5		
19	32	12	24.1		
20	31	18	27.8	-67.9	-78.3
21	33	18	26.5		

CONT'D FEBRUARY 1953					
22	37	11	27.5		
23	42	23	36.0		
24	44	25	38.2		
25	53	30	43.9		
26	44	27	36.8		
27	52	33	40.0		
28	53	31	45.9		
MARCH 1953					
1	55	32	44.3	-69.1	-70.4
2	41	32	37.3	-66.8	-80.3
3	39	27	34.2	-68.8	-79.6
4	39	25	35.4	-70.6	-75.1
5	44	31	38.5	-72.0	-74.8
6	48	30	41.5		
7	46	33	42.5	-62.7	-76.2
8	45	30	38.7	-69.3	-77.4
9	51	32	41.5	-70.8	
10	47	38	42.8	-65.2	-86.1
11	47	34	41.4	-49.5	-76.2
12	42	32	38.4		
13	41	30	37.0		
14	44	29	39.7	-69.7	
15	47	28	39.4	-64.3	
16	51	32	46.0	-58.4	-69.5
17	53	33	46.3	-68.8	-71.0
18	58	34	49.6	-73.8	-77.8
19	53	37	47.4		
20	54	44	49.5	-53.5	
21	58	44	51.8		
22	54	37	47.2		
23	54	43	50.2	-67.0	-71.3
24	53	41	49.7	-60.7	-67.9
25	49	33	37.4	-61.6	-72.4
26	45	29	37.4	-73.1	
27	55	33	47.2	-66.1	-65.2
28	55	36	48.5	-47.2	-61.2
29	53	36	46.5		
30	50	33	46.9	-59.6	-72.2
31	56	33	48.0	-66.1	-77.8

APRIL 1953

1	53	37	46.7		
2	55	35	47.9		
3	59	40	51.7	-58.0	-72.4
4	54	38	48.4	-66.6	-72.6
5	56	43	49.8	-59.8	-71.9
6	57	37	50.3	-67.2	-73.3
7	60	36	51.4	-71.0	-76.9
8	63	36	52.5	-80.1	-77.6
9	60	41	54.3	-73.1	
10	67	45	57.3		
11	54	39	51.0	-69.9	
12	50	37	45.0	-62.7	-68.1
13	55	39	51.0	-67.0	-68.4
14	60	40	53.3	-77.6	-74.2
15	61	42	56.0	-69.9	-76.0
16	59	40	53.0	-62.3	-74.2
17	60	35	52.5	-63.6	-72.9
18	59	39	53.1	-60.9	
19	63	38	55.8	-58.4	-66.8
20	57	40	52.3	-61.6	-74.4

PREFLIGHT INSPECTION

1. Check air pressure. Thaw and drain air bottle.
2. Inspect gun mounts, electrical connection, harness, and general condition of the gun bay.
3. Apply power to aircraft. Be sure air compressor starts operating and check for air leaks.
4. Check firing circuit with magic wand.
5. Inspect ammunition boxes, link chutes, ammunition chutes, case ejection tubes, feeder and drum shafts, muzzle stabilizer and gas seals.
6. Secure link compartment doors and barrel access doors.
7. On instruction from pilot, charge guns and inspect chamber to insure that a round is in the firing position and operating slide is completely forward.
8. Install gun bay doors, close ammunition compartment doors and install the leading edge.

POSTFLIGHT INSPECTION

1. Determine and record stoppages and number of rounds fired.
2. Clear all guns.
3. Remove and inspect the following:
   a. Barrel.
   b. Drum seals.
4. Replace the following:
   a. Anvil assembly with clean and electrically checked assembly.
   b. Cracked seals.
   c. Barrels with eroded faces or cracked orifices.

5. Inspect remainder of gun for worn or defective parts.

6. Reassemble and cycle gun to insure free operation.

7. Check all safetying devices.

8. Remove expended links.

9. Check firing circuit with magic wand and insure anti-double feed device operates correctly.

10. Reload and install ammunition cans.

11. Charge two (2) rounds into drum.

12. Replace and/or close all doors.

13. Report to shop the status of the airplane.

PRE-INSTALLATION GUN INSPECTION

NOTE: This inspection is performed on all new guns prior to use.

1. Complete disassembly of weapon.

2. Inspect all parts for wear or breakage.

3. Replace any parts determined unserviceable in #2.

4. Replace all the following parts:

   a. Old type ADS spring with new type.

   b. Steel piston with titanium piston.

5. Reset recoil springs as per instructions.

6. Reassemble weapon checking items listed in #7.

7. Check List:

   a. Insulation value of anvil assembly and harness with 500 V meg meter.

b. Circuit continuity of anvil assembly and harness with volt ohmmeter.

c. ADF contact fit with ADF pawl.

d. Roller clearance in cam path.

e. Safetying of all parts.

f. Position and tightness of gas tube.

g. Fit of gas piston (.005 to .020 under flush.)

8. Check clearance on front mounting lugs and file where necessary.

9. Tap rear mount holes to remove burrs, etc.

INTERMEDIATE INSPECTION

NOTE: This inspection is performed in the shop at the one half life of the gun (1200 to 1500 rounds).

1. Complete disassembly of weapon.

2. Clean all parts.

3. Inspect all parts for wear and breakage.

4. Replace any parts determined unserviceable in #3.

5. Replace all the following parts:

a. Cam insert screws.

b. Seals.

c. Harness screws.

d. Follower spring.

e. Round retainer spring.

f. ADF Spring.

6. Reset recoil springs as per instructions.

7. Reassemble weapon checking items listed in #6.

8. Check list:

   a. Insulation value (meg meter).

   b. Circuit continuity (volt meter).

   c. ADF contact fit with ADF pawl.

   d. Roller clearance in cam path.

   e. Safetying of all parts.

   f. Position and tightness of gas tube plug.

   g. Fit of gas piston to forward face of cylinder (.005 to .020 under flush).

ANVIL CLEANING CHECK LIST

NOTE: Anvils are cleaned daily according to the following procedure.

1. Complete disassembly of anvil assembly.

2. Inspect for broken parts and cracked insulation.

3. Clean rust, corrosion and carbon off metal parts with crocus cloth.

4. Clean with alcohol.

5. Ream inside of drawbar with size #20 drill.

6. If necessary face off front of firing pin insulation with 1/8" drill.

7. If necessary ram firing pin hole in anvil insulation with size #48 drill.

8. Assemble anvil.

9. Check firing pin protrusion with flush pin gauge. (Reject if under .025" or over .034".)

10. Check insulation value with meg meter.

11. Check circuit continuity with volt ohmmeter.

INSTRUCTIONS FOR SETTING RECOIL SPRINGS

1. Remove cover and inspect for broken elements. Replace cover.
2. Remove cotter pin.
3. Place in preload device, compress to 3500#.
4. Back off preload nut three (3) turns.
5. Return spring to 0# load.
6. Compress to 3500# and return to 0# twice more.
7. Compress to 1100# and tighten preload nut.
8. Compress to 2600# and return to 0#.
9. Compress to point where preload nut releases.
10. If preload nut release between 1000# and 1100# then confirm setting by:

    a. Compress to 2600# then release to 0# and repeat step #9.

11. If preload nut does not release between 1000# and 1100#, adjust nut and repeat steps 8, 9, and 10.
12. Remove from calibrating device and inspect for broken elements.
13. Replace cotter pin.

INSTRUCTIONS FOR DRILLING BARREL ORIFICE

NOTE: Most barrels are received with a .187" diameter orifice. This orifice must be drilled out to .199" to gain increased cyclic rate. Some barrels have been received with a .193" or a .203" diameter orifice. The .193" diameter orifice can be drilled in the same manner as the standard .187" orifice. The .203" diameter orifice should be installed as is.

1. Remove all burrs from the barrel, locking threads and bearing surfaces with a fine file.

2. Place barrel in drill jig.

3. Place locating pin in barrel orifice and tighten set screw.

4. Drill barrel with size #8 drill. Use one new high speed #8 drill on each two barrels. Do not force the drill. Apply an even light pressure to the drill.

5. Remove barrel from drill jig.

6. Inspect orifice for cracks or misalignment and brush away any shavings from drilling.

7. Try barrel in gun to check for proper fit.

PHOTOGRAPHS

OF

ARMAMENT MALFUNCTIONS

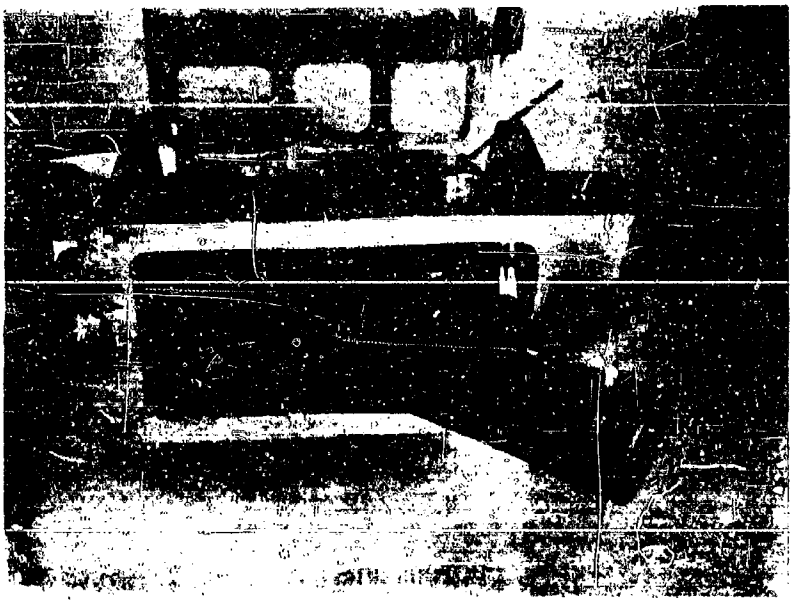


PHOTO #1 - "FEEDER"

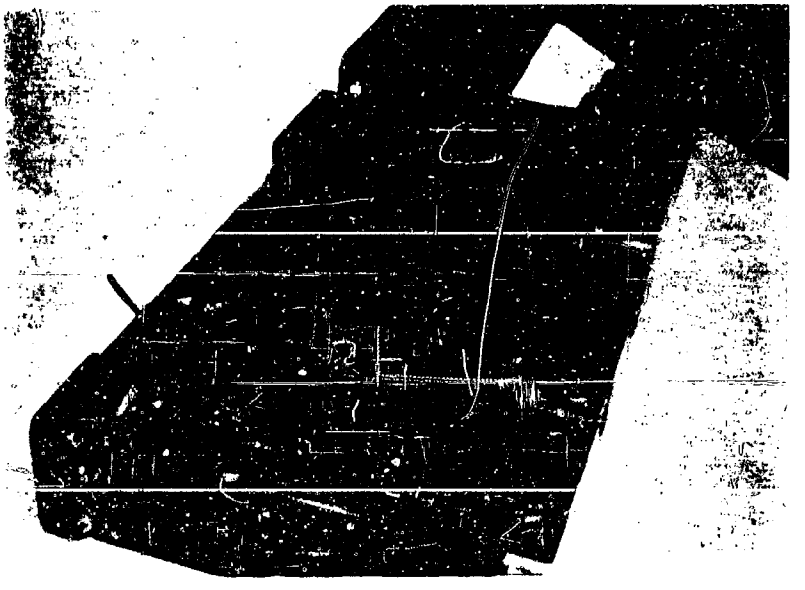


PHOTO #2 - "SLIDEWAY WELDS"

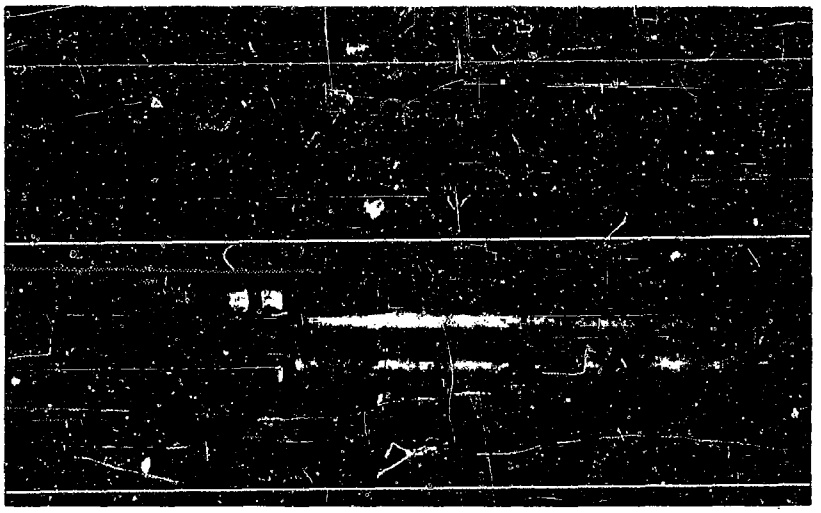


PHOTO #3 - "TITANIUM PISTON"

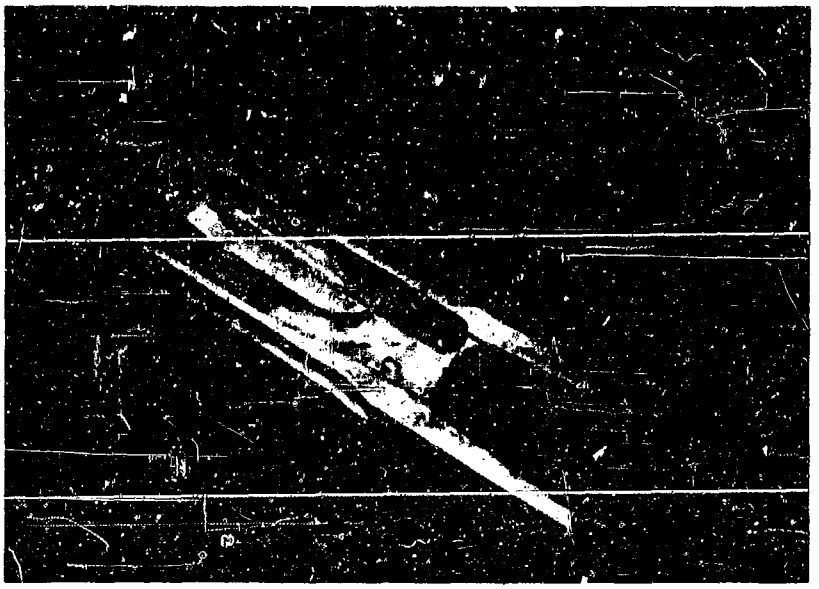


PHOTO #4 - "SWITCH CAM EARS"

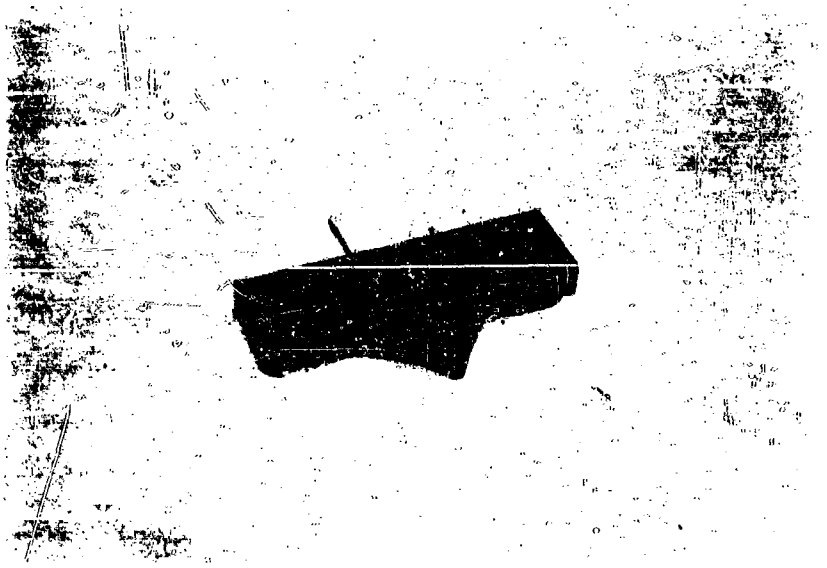


PHOTO #5 - "CAM INSERT"

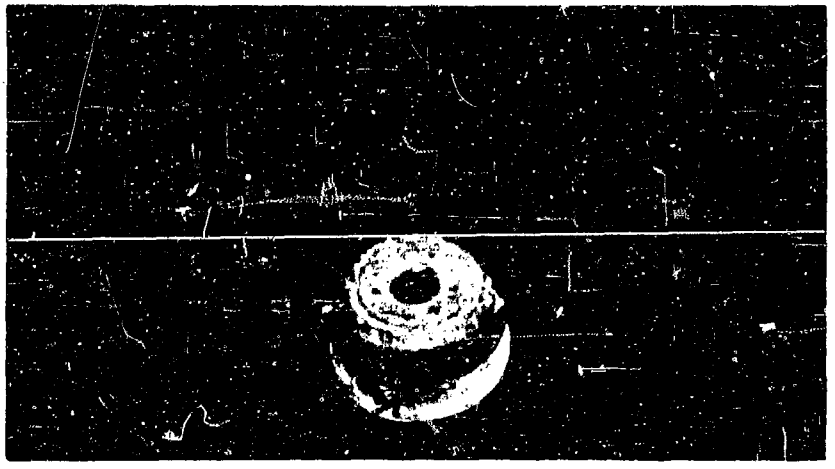


PHOTO #6 - "GAS CYLINDER PLUG"

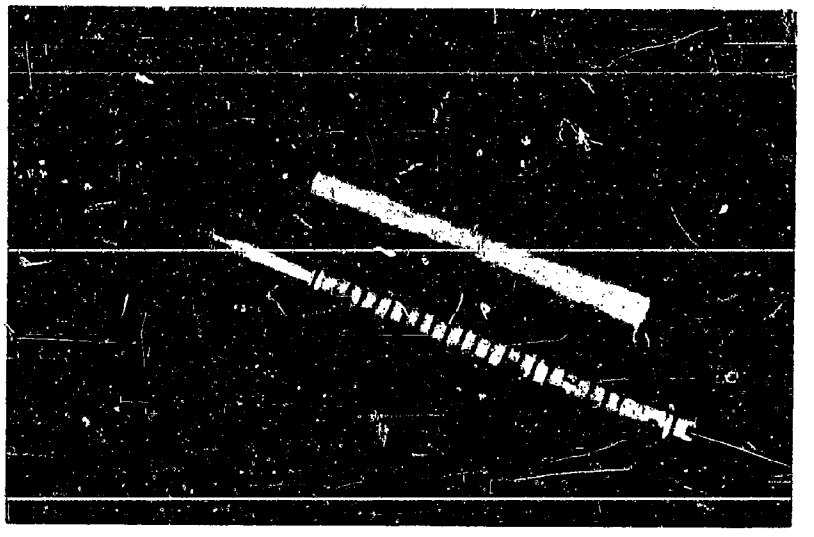


PHOTO #7 - "RECOIL SPRING ELEMENTS"

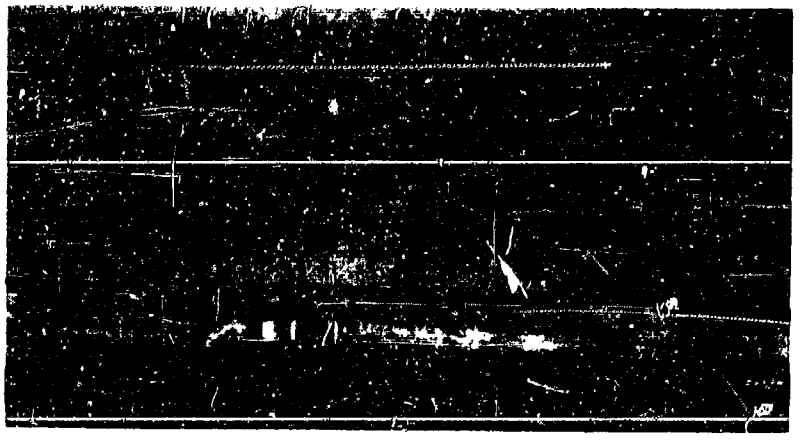


PHOTO #8 - "BARREL ORIFICE"

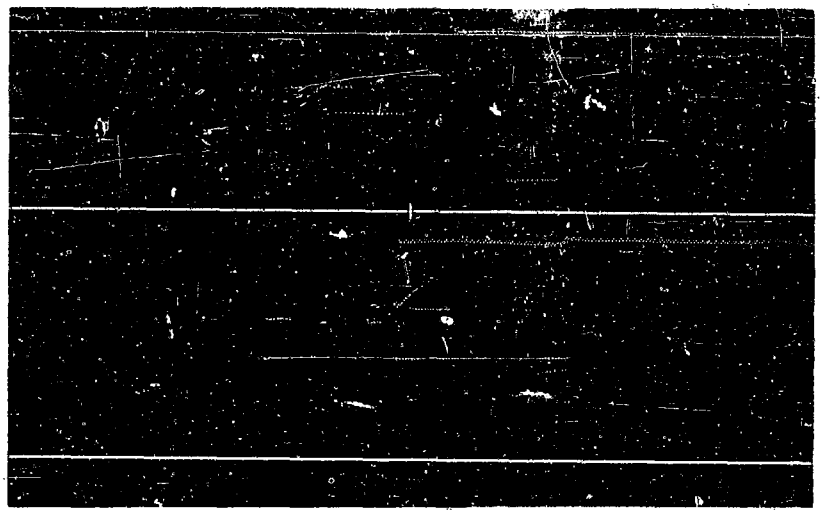


PHOTO #9 - "BARREL FACE"

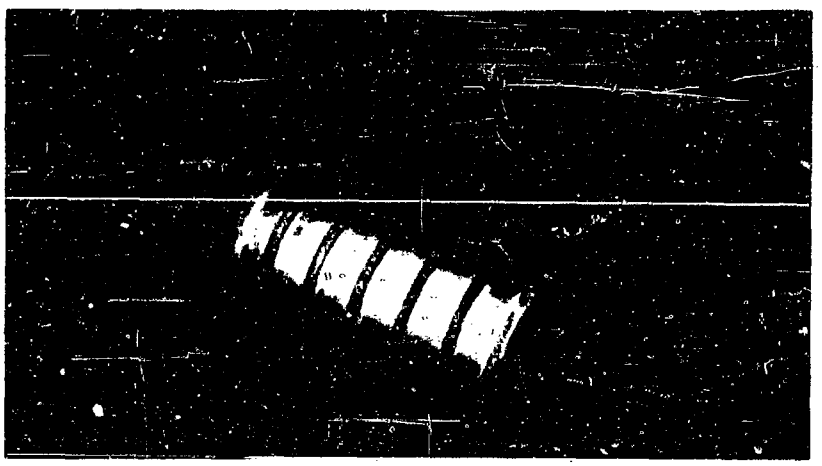


PHOTO #10 - "DRUM SEAL"

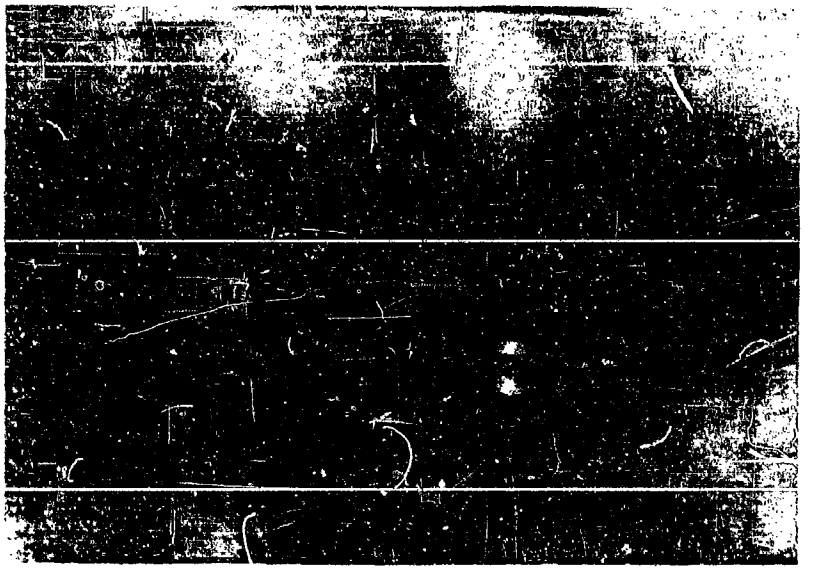


PHOTO #11 - "ANVIL ASSEMBLY"

PHOTO #12 - "HARNESS ASSEMBLY"

PHOTO #13 -- "BROKEN FIRING PIN SPANNER NUT"

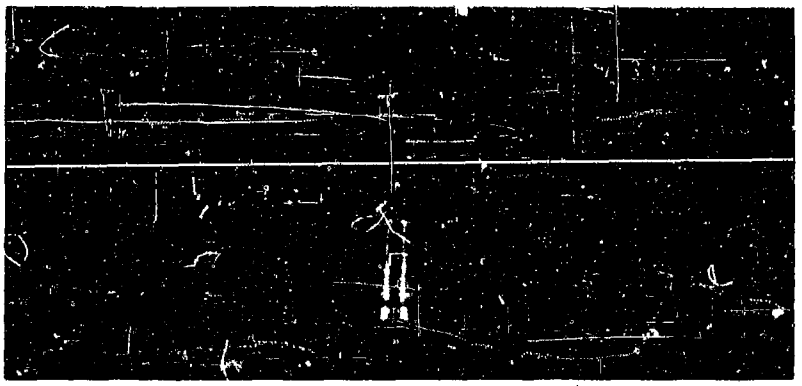


PHOTO #14 - "CRACKED FIRING PIN"

PHOTOS 15 & 16 - "BROKEN FIRING PIN DRAWBARS"

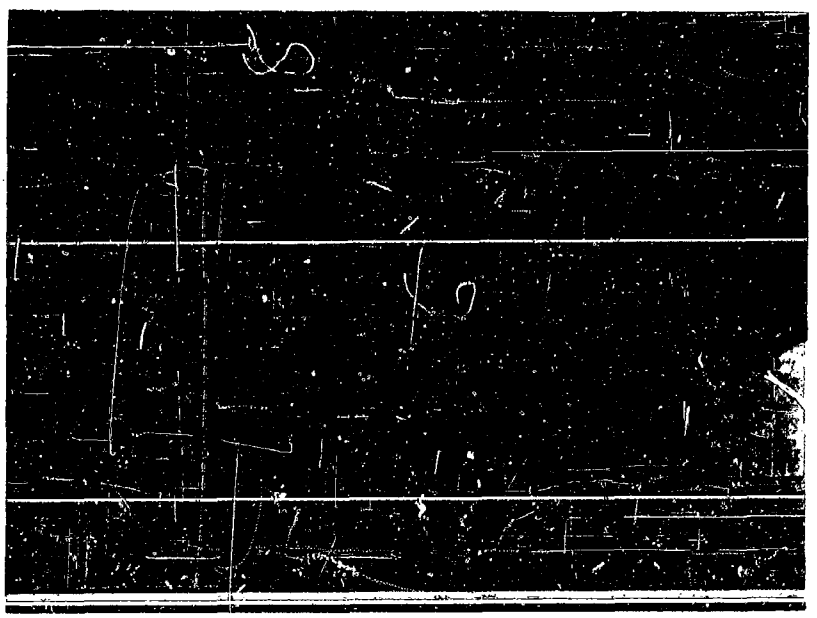


PHOTO #17 - "DAMAGE TO BLAST PANEL (HEI AMMUNITION)

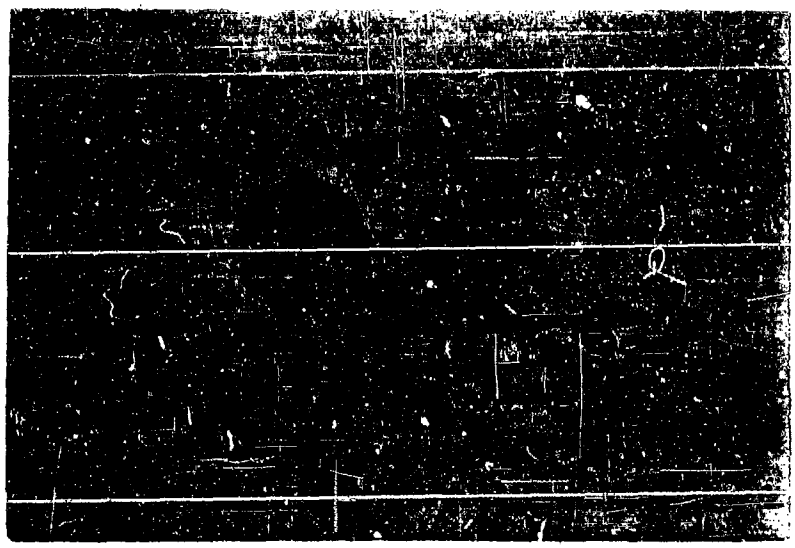


PHOTO #18 - "SHEARED RIM OF CASE"

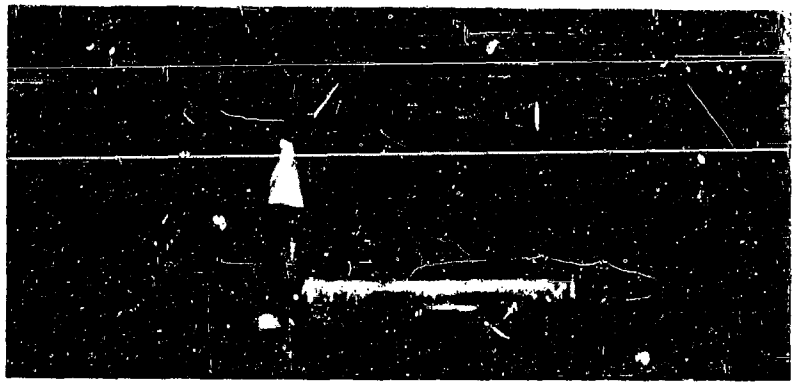


PHOTO #19 - "DEBULLETED ROUND"

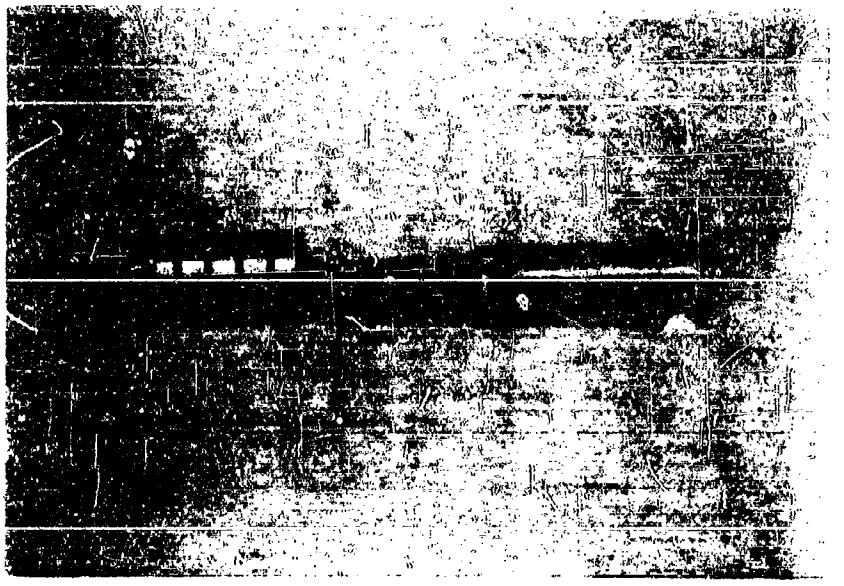


PHOTO #20 - "DEBULLETED RD (180°)

PHOTO #21 - "DEBULLETED RD"

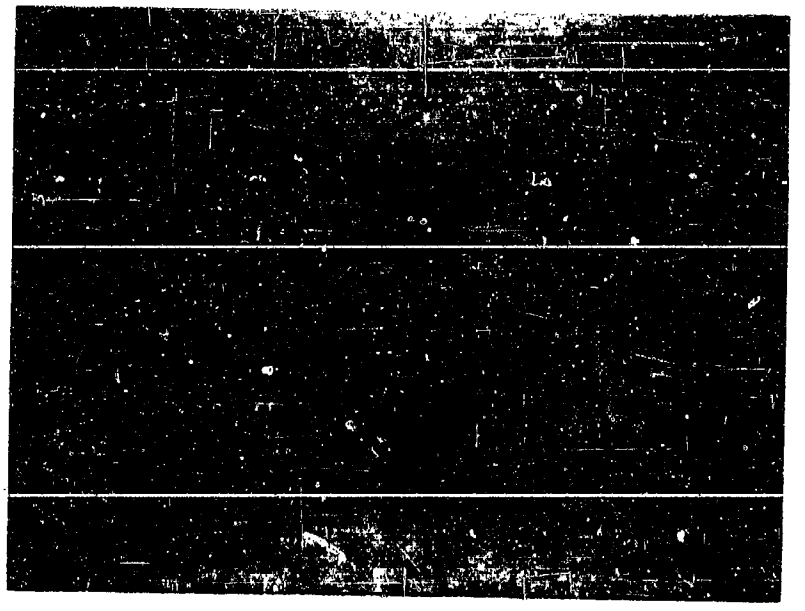


PHOTO #22 - "OVER LENGTH CASE"

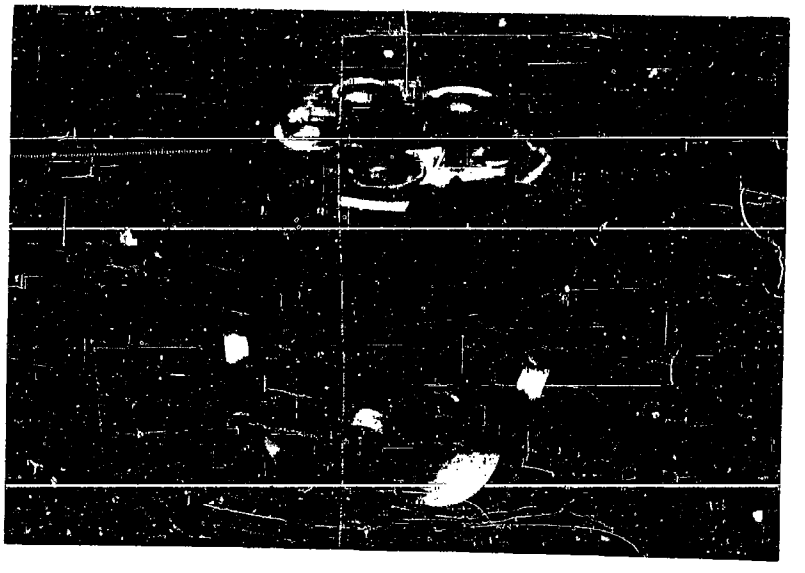


PHOTO #23 - "UNUSUAL POWDER BURNS"

AMMUNITION BURSTS

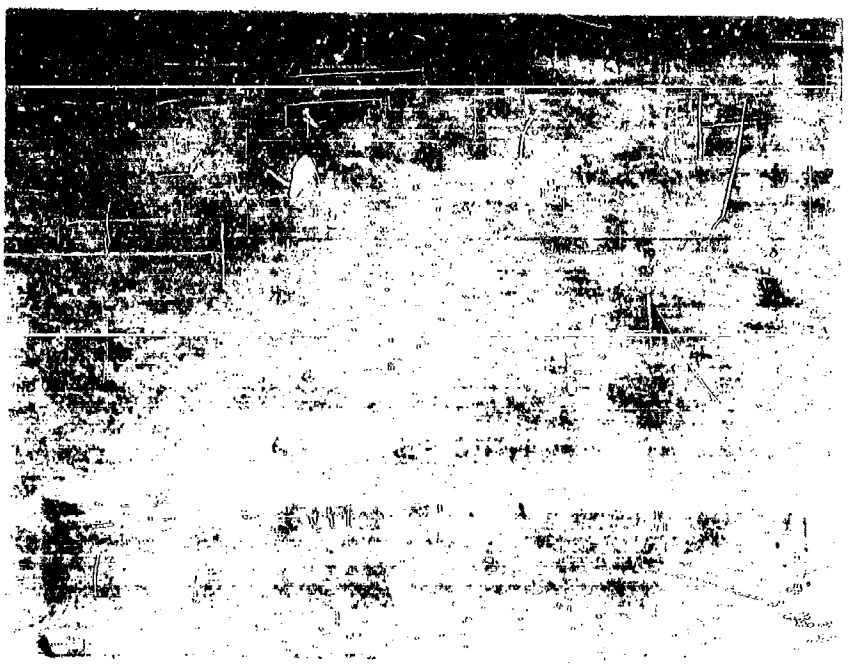


PHOTO #24

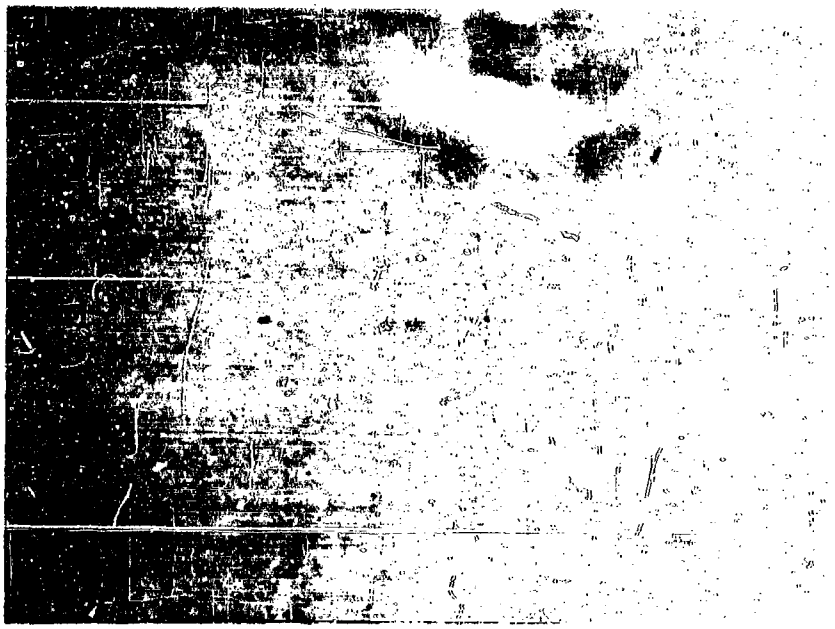


PHOTO #25

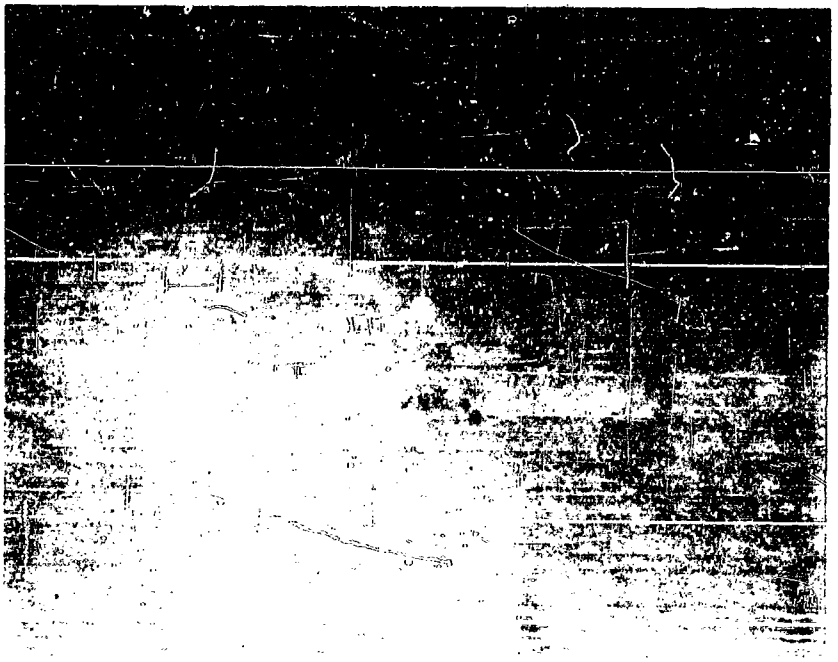


PHOTO #26

SPECIAL TOOLS

The following tools and equipment should be provided in addition to the regular set of tools issued to weapons mechanics.

FLIGHT LINE MAINTENANCE

1. "Magic Wand"
2. Ohmmeter (1½ volts)
3. Operating Spring Tool
4. Ammo Loading Hooks
5. Hand Charging Cables
6. Lead Mallet
7. Raw Hide Maul
8. Allen Wrenches - #10, 1/4, 5/16, 3/8 and 7/16 inches.
9. Long Drive Pin Punches - 3/22, 1/8, 3/16 and 7/16 inches.

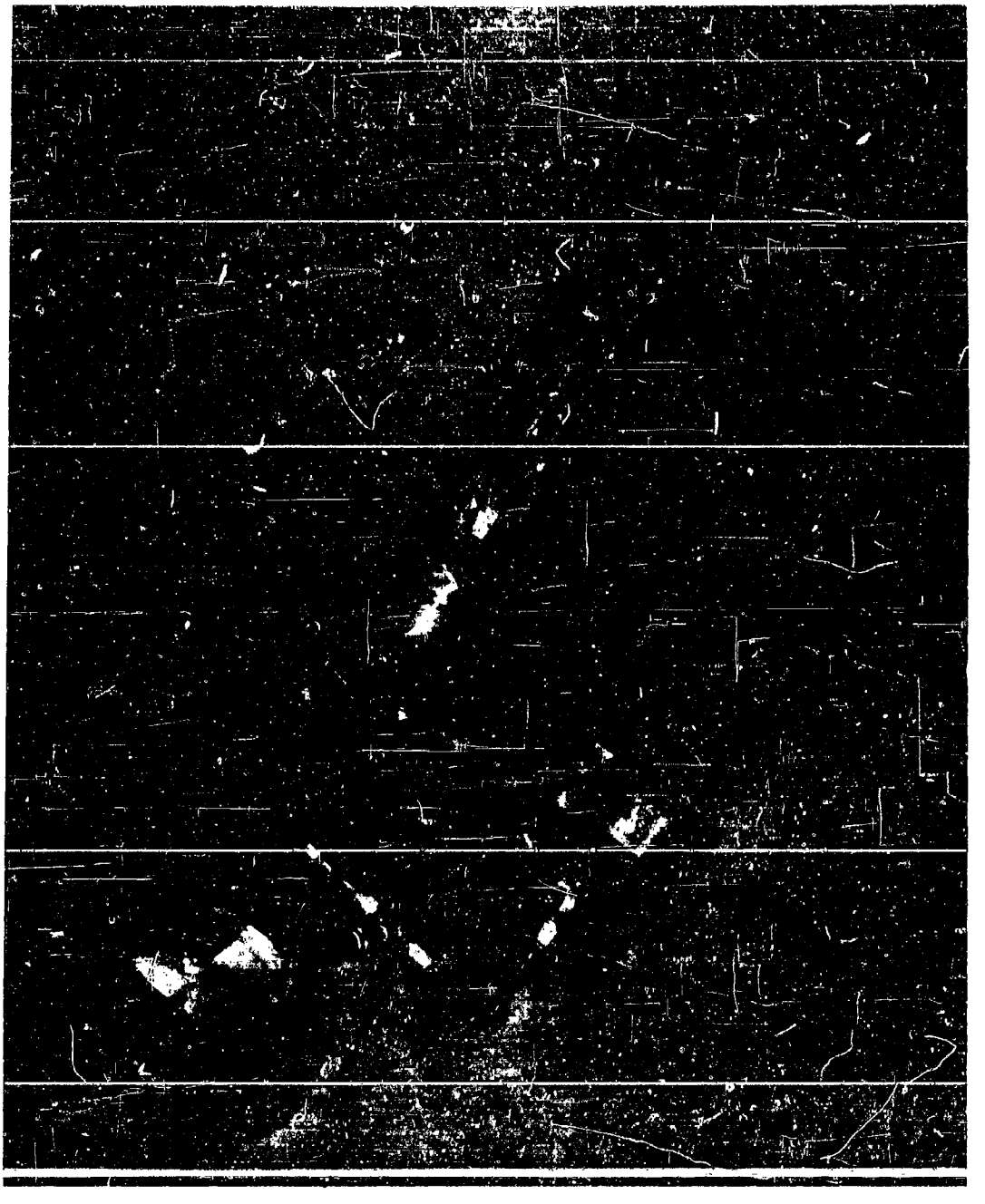
SHOP MAINTENANCE

1. Firing Pin Retainer Wrench
2. Recoil Spring Retainer Spanner Wrench
3. Gas Cylinder Plug Spanner Wrench
4. Barrel Jig (see photo)
5. Meg Meter 500V
6. Volt - Ohmmeter
7. Emery and Buffer Wheel
8. Cotter Pin Removal Tool
9. Recoil Spring Preload Setting Machine (Photo)

AMMO AREA

1. Hand Linkers
2. Machine Linker
3. Ammo Can Opener

BARREL JIG



RECOIL SPRING PRELOAD SETTING MACHINE

PHOTOGRAPHS

OF

GUN MODIFICATIONS

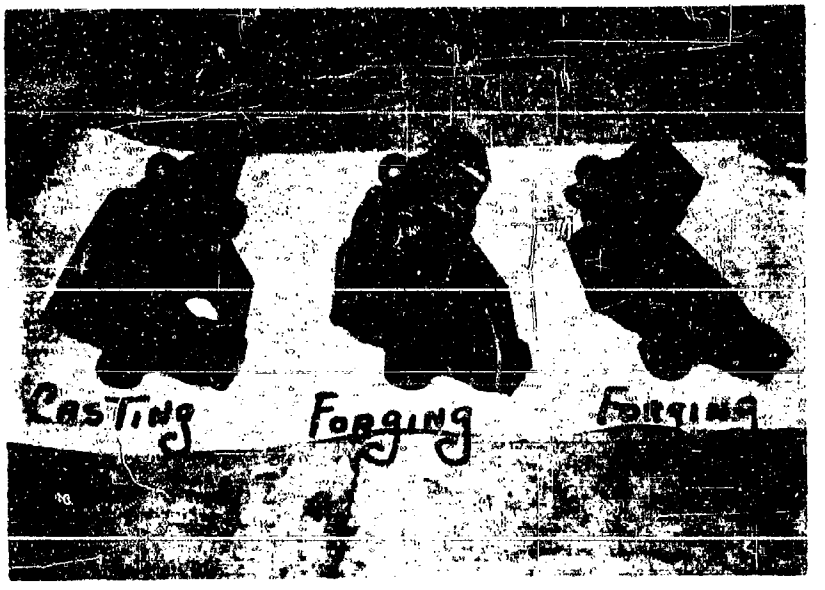


PHOTO #1 - DRUM CRADLES"

PHOTO #2 - "INTERFERENCE AREAS OF UNMODIFIED FORGED DRUM CRADLES"

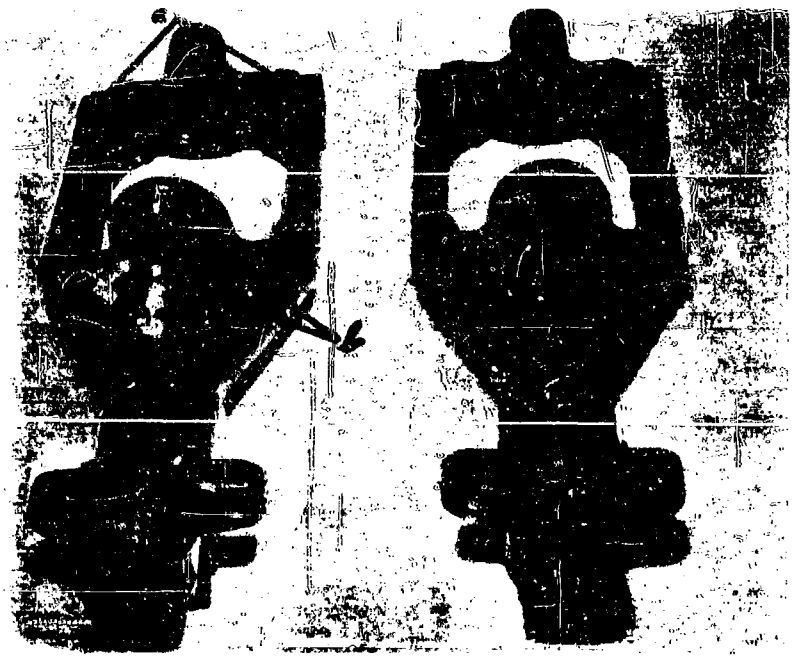


PHOTO #3 - "DRUM CRADLE MODIFICATION"

a. Extractor Spring Counter Bore Deepened 1/4".

b. Barrel & Drum Shaft Latch Holes Threaded for NAA Lock Pins.

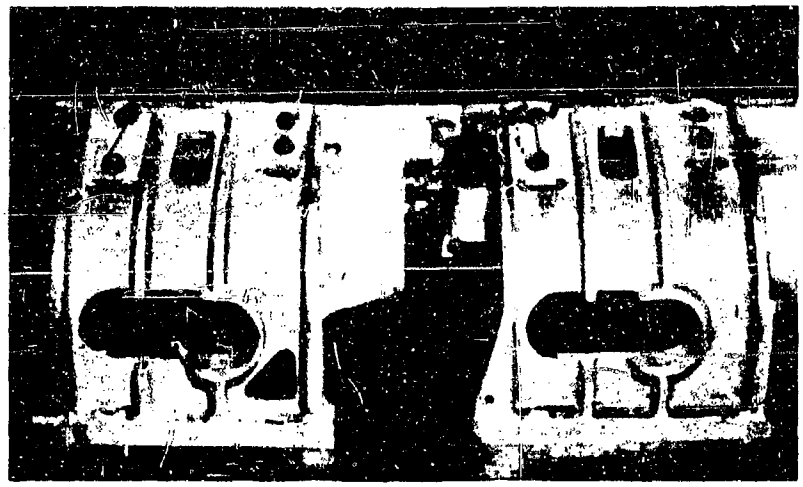


PHOTO #4 (a. Modified Feeder.) (b. Original Feeder.)

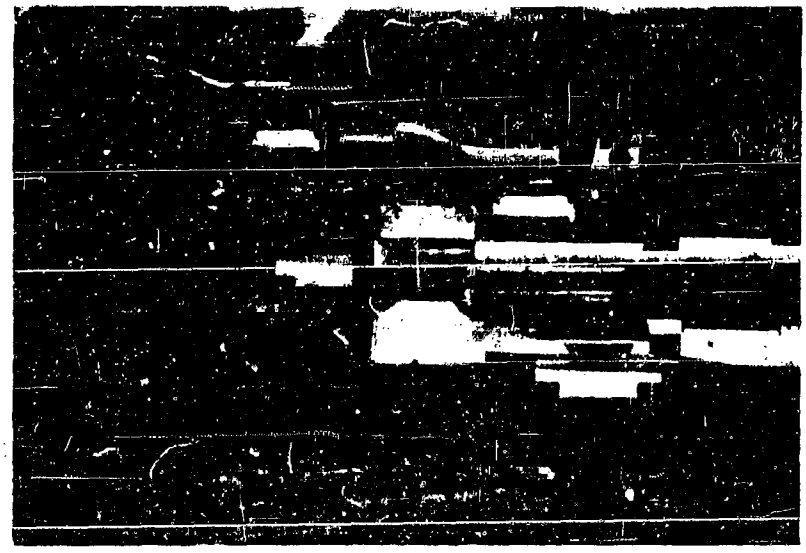


PHOTO #5 (a. Original Operating Slide Assy.)
(b. Modified Operating Slide Assy.)

PHOTO #6 (a. Original Feeder Link Guide.)
(b. Modified Feeder Link Guide.)

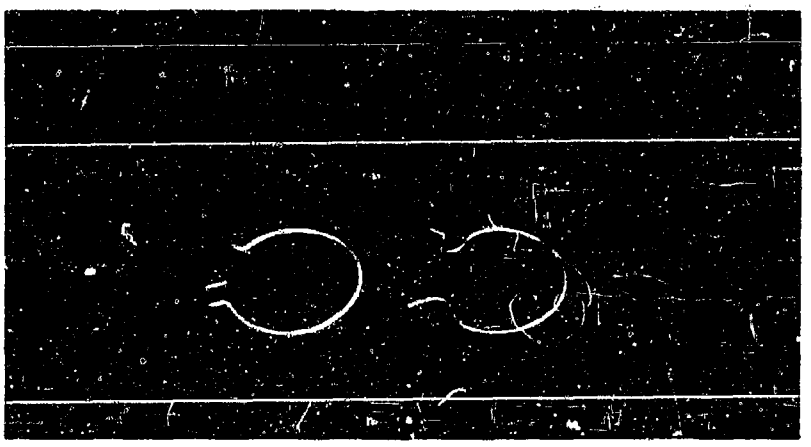


PHOTO #7 - "Original & Modified A.D.F. Springs"

PHOTOGRAPHS

OF

INSTALLATION MODIFICATIONS

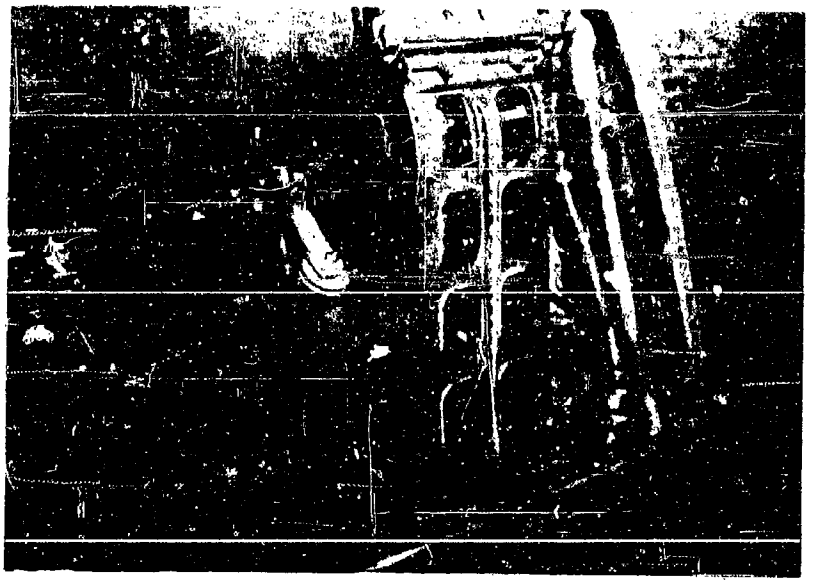


PHOTO #1 - "REMOVAL OF UPPER LINK CHUTES AND SCREENING USED TO CONTAIN LINKS IN GUN BAY AREA."

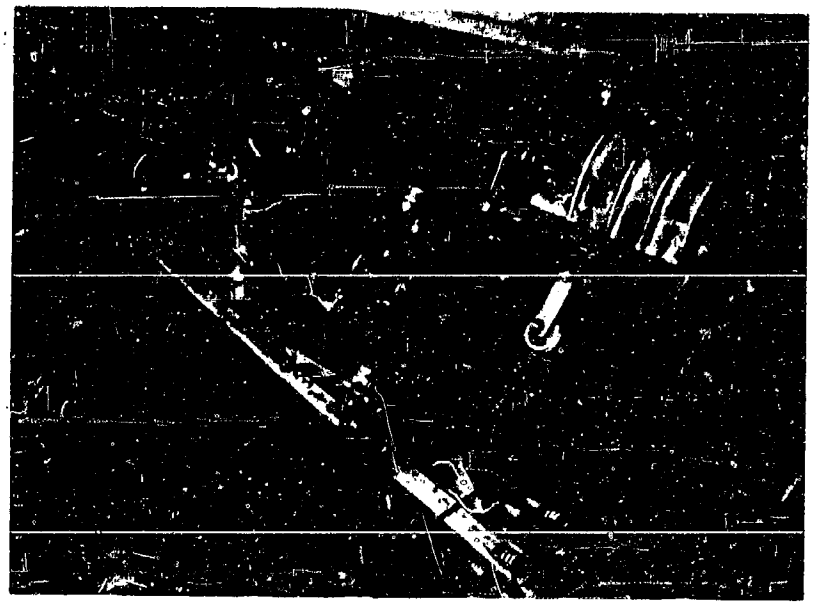


PHOTO #2 - "REMOVAL OF LOWER LINK CHUTES & HOPPER EMPLOYED TO FUNNEL LINKS INTO LINK COMPARTMENT."

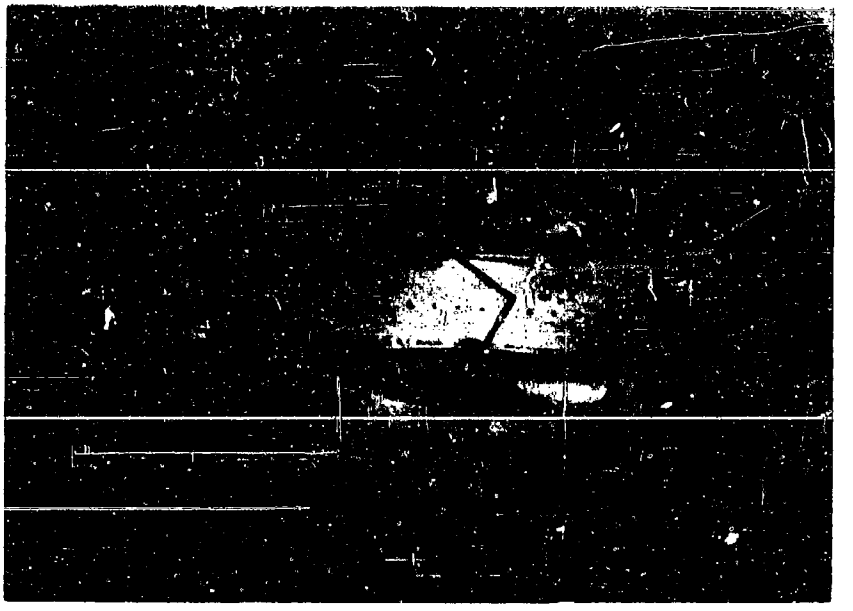


PHOTO #3

GAS DEFLECTORS INSTALLED TO REDUCE COMPRESSOR STALLS CAUSED BY MUZZLE FLASHES. THE EFFECTIVENESS OF THIS MODIFICATION WAS LIMITED.

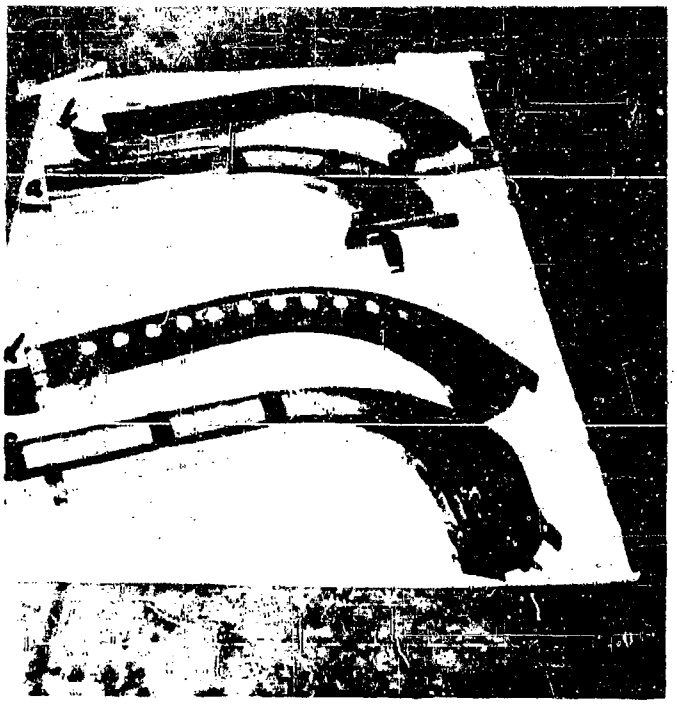
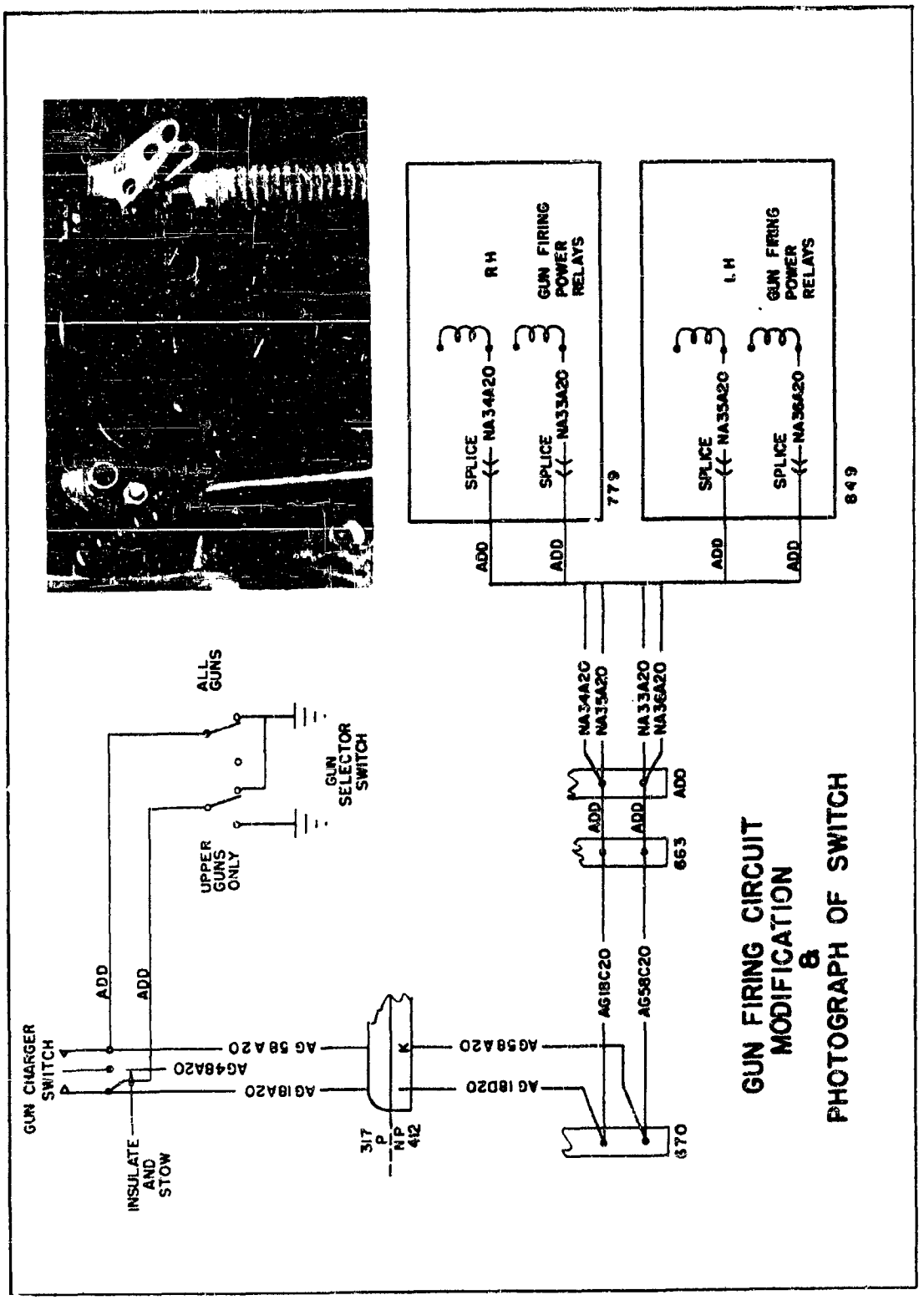


PHOTO #4 - "ORIGINAL AND MODIFIED LINK CHUTES"

(a. Original L. H. Lower Chute) (b. Modified L. H. Lower Chute)

(c. Original L. H. Upper Chute) (d. Modified L. H. Upper Chute)


GUN FIRING CIRCUIT
MODIFICATION
&
PHOTOGRAPH OF SWITCH
R H
GUN FIRING POWER RELAYS
L H
GUN FIRING POWER RELAYS
SPLICE
NA34A20
SPLICE
NA33A20
SPLICE
NA35A20
SPLICE
NA36A20
779
849
ADD
NA34A20
NA35A20
NA33A20
NA36A20
663
670
AG18C20
AG58C20
ALL GUNS
GUN SELECTOR SWITCH
UPPER GUNS ONLY
GUN CHARGER SWITCH
AG 58A20
AG48A20
AG18A20
INSULATE AND STOW
317
P
NP
412
K

PHOTOGRAPHS

OF

AMMUNITION FAILURES

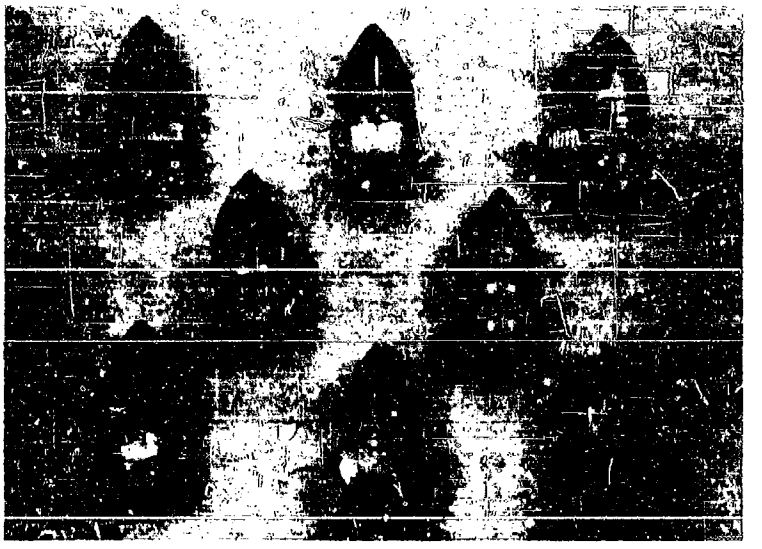


PHOTO #1 - "STRIPPED ROTATING BANDS"

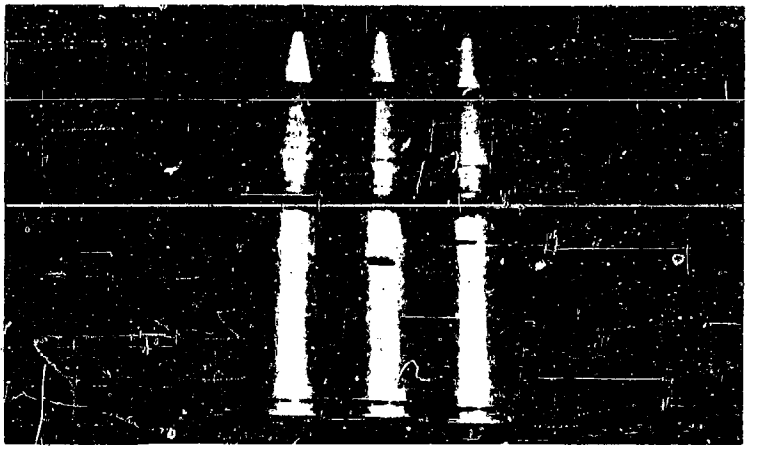


PHOTO #2 - "H.E.I. AMMUNITION WITHOUT PROPELLENT"

APPENDIX F

FIRE CONTROL SYSTEM

This appendix covers the operation and maintenance of the Fire Control System on eight (8) F-86F-2 aircraft equipped with T-160, 20 mm guns. The period of this report is 11 January 1953 to 1 May 1953.

These aircraft are equipped with the standard MA-3 Fire Control System consisting of the AN/APG-30 radar and the A-4 gun bomb rocket sight. The Range Servo is the standard RS-311 with the exception of the positioning mechanism. Positioning mechanism ME-118 for .50 caliber has been replaced by positioning mechanism ME-150 for 20 mm.

Instrumentation to the Fire Control System consists of the APGC range limiter and a pilot's radar "lock-on" sensitivity control.

Upon arrival of the aircraft at Kisarazu AFB, Japan, a modified NAA computer bracket was installed on all computers. The eight (8) pound shock mounts manufactured by Lord Manufacturing Company was replaced with Robinson MET-L-FLEX shock mounts. This was done in an effort to reduce reticle vibration. Reticle camera film and pilot's comments indicate that vibration was reduced by approximately 50%. Photographs of both the old and new computer brackets and shock mounts are inclosed in this appendix.

1. Fire Control System Reliability:

   a. General

Maintenance to the Fire Control System was the same as the maintenance procedure outlined by the consolidated Radar and Gun Sight shop of the 4th Fighter Interceptor Wing. This consisted of complete slope and zero calibration of the radar and G-3 system analyzer test of the sight every three (3) days. Daily preflight inspection consisted of an operational test of the system plus measuring of all power supply voltages by use of the TS-352 multimeter.

A total of 284 combat missions were flown during the period of this report. Pilots reported a malfunction of the system on 29 of these missions. Postflight inspection of the system by use of the test equipment failed to reveal a discrepancy on six of these reports, and satisfactory operation was obtained on the next mission without any adjustment to the system. A total of 23 malfunctions were discovered by maintenance personnel during slope

and zero tests and preflight inspection. This makes a total of 46 malfunctions to the Fire Control System during the period.

b. APG-30 Radar

Upon arrival of the aircraft at K-14, acceptance inspections were performed on all sets. Slope and zero calibration tests were made during this inspection, and all sets were found to be operational. A check of each set was made at this time to determine if all the manufacturer's modifications, as outlined in AN-16-30 APG 30-3, dated 15 November 1952, had been complied with. It was found that all modifications had been made. However, after a discussion with the General Electric technical representative at this station, it was decided that modification 34 should be deleted. The purpose of modification 34 was to eliminate the selectivity of V-108 (2D21) tubes in the range transmitter. In doing so, it had been found by "Project Jaybird" that it also eliminated the overload protection feature of the circuit. The circuit affected by modification 34 was returned to its original status. This accounts for the high consumption rate of 2D21 tubes.

A total of 30 malfunctions occurred to the radar sets during the period of this report. Of this number, eighteen required replacement of parts, and twelve required adjustments.

Radar sets were removed for bench checks at all intermediate inspection periods, and at other times when a malfunction was of a nature that it could not be analyzed with the test equipment normally used on the aircraft.

c. A-4 GBR Sight

Acceptance inspection to the sight included a G-3 system analyzer test. This test showed all sights were operational upon arrival at this station.

A total of eight malfunctions occurred to the sight during this period. All the sight malfunctions required replacement of parts. Following is a list of aircraft and dates at which calibration tests of the sight were made. The procedure for this test is outlined in Sperry Engineering Specification No. 667493 as modified by A.O. 22190 for 20 mm prediction angle sensitivity. Also listed is the total number of rounds that had been fired through each aircraft at the time of the test.

Aircraft No.	Date	
868	25 Feb 1953	After 10,611 rounds
819	27 Feb 1953	" 9,000 rounds
826	7 Apr 1953	" 15,284 rounds
836	9 Apr 1953	" 15,165 rounds
803	22 Apr 1953	" 11,798 rounds
867	24 Apr 1953	" 22,226 rounds
855	24 Apr 1953	" 11,933 rounds

These tests showed that all the specifications still fell within the manufacturer's tolerances. Little or no change had taken place since tests were run at the beginning of the program at Edwards AFB, California.

d. Range Servo

There were eight malfunctions of the Range Servo during this period, all of which required replacement of the plug-in components.

2. Description of Difficulties

a. The following is a list of parts replaced to correct malfunctions.

(1) Radar

13 ea	2D21 tubes
1 ea	5517 tube
1 ea	Directional coupler
2 ea	5 Amp. 3 AG fuzes
1 ea	AFC crystal

(2) Sight

3 ea	Sensitivity amplifier (plug-in unit)

1 ea	Amplifier chassis
1 ea	Range drive motor (sight head)
2 ea	Range amplifier (plug-in unit)
1 ea	.2 mfd capacitor

(3) Range Servo

1 ea	Power supply
1 ea	Modulator
2 ea	Amplifier
1 ea	Adapter
1 ea	Chassis
2 ea	ME-150 Positioning Mechanism

3. Conclusions:

It is concluded that the MA-3 Fire Control System, as modified by positioning mechanism ME-150 to provide prediction angle sensitivity for 20 mm ammunition, is suitable for use in aircraft equipped with the T-160 guns.

Visual inspection of both the interior and exterior of all components during calibration tests showed that the system suffered no damage as a result of the increased forces imposed on it by the 20 mm guns.

APPENDIX G

CAMERA INSTALLATION

1. GENERAL:

The camera installation in these test aircraft included the normal scoop arrangement with AN-6 camera. In addition to the scoop camera, the aircraft were equipped with a sight reticle camera which recorded the sight reticle in addition to the target. The original erector head for this reticle camera was found unsuitable since it restricted the pilot's vision to a large extent. The erector head in this installation was 1½ inches in width. To correct this deficiency a new erector head manufactured by the Zoomar Company was installed. This new erector head was 5/8" in width and was considered desirable and acceptable from the point of view of restriction in vision. The features of the Zoomar erector head which permit a reduction in width to 5/8" is the addition of a lens in the assembly itself. In the installation in these test aircraft, the camera was mounted in an inverted position. By the addition of this extra lens, the resulting image was also inverted. This was found to be undesirable and the camera should be mounted in an upright position in future installations. In addition, the set screws on the erector head were found to be too small, therefore could not be tightened sufficiently to prevent rotation of the erector head due to vibration. It was also observed that the back plate on the erector head where the manufacturer's name and serial number were located was painted white. This portion of the head is in direct line of sight between the pilot and the target and proved to be distracting. Included as Inclosure #1 is photograph of old and new reticle camera installations.

2. RELIABILITY:

During this test 284 combat missions were flown. Black and white film was used in the reticle camera and Kodak color film was used in the scoop camera. A total of 114 black and white film magazines were processed, a total of 60 color magazines were forwarded to the Air Proving Ground Command for processing. Out of 582 magazines expended on firing missions during this test, 98% ran without mishap. The malfunctions which occurred were as follows:

a. Five camera malfunctions.

b. Six magazine malfunctions.

c. Three wiring malfunctions.

3. RECOMMENDATION:

It is recommended that a spring loaded switch be placed in the cockpit in future installations so that the cameras may be inoperative during preflighting of the guns. Preflight procedures for this electrically fired gun require that checks be made of the electrical firing circuit on the ground. If the cameras are operated needlessly during the checking of the gun electrical system, this will shorten the life of the camera.

PHOTOGRAPHS SHOWING OLD AND NEW RETICLE CAMERA INSTALLATIONS

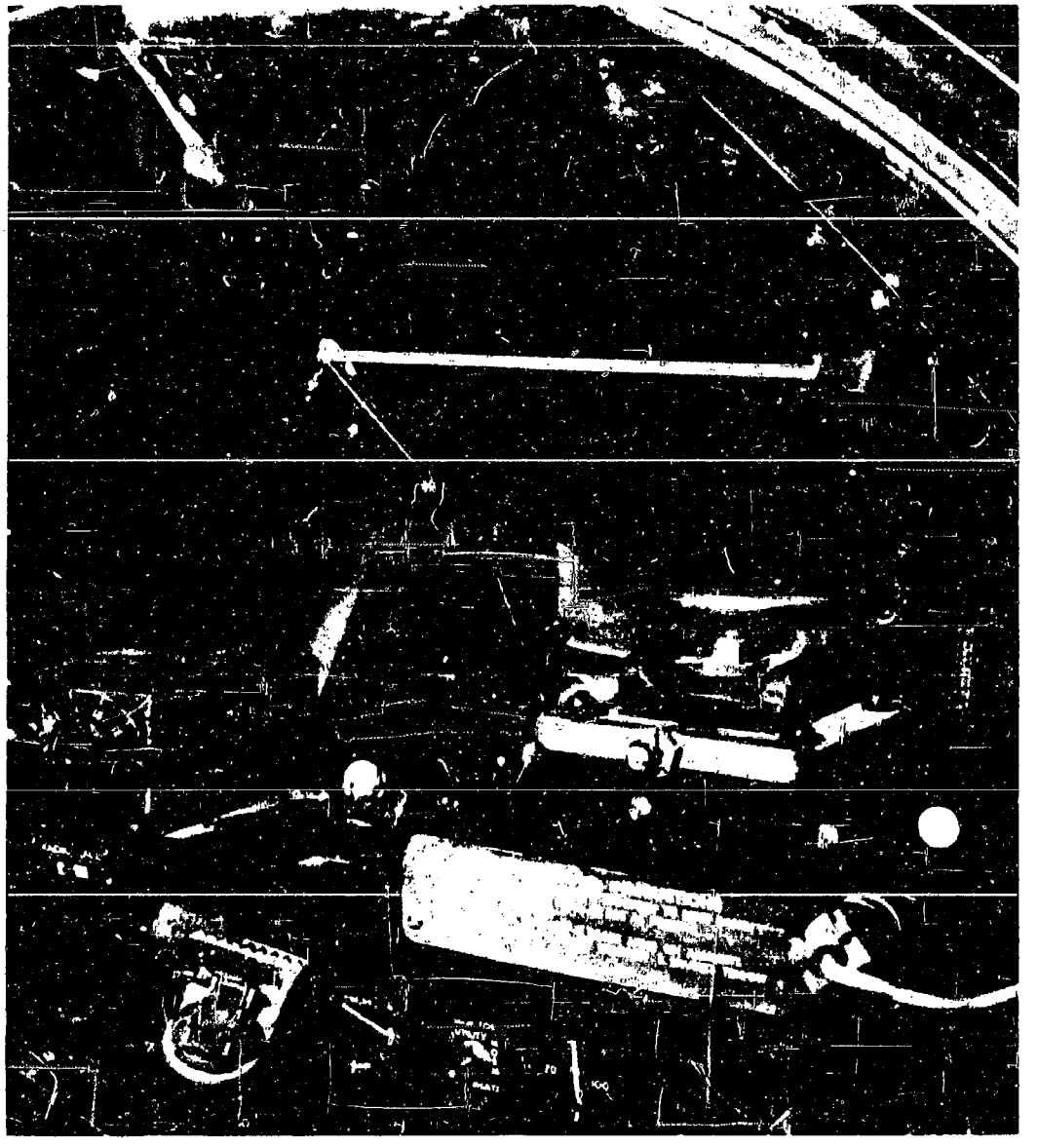


PHOTO #1

NAA CAMERA ERECTOR HEAD

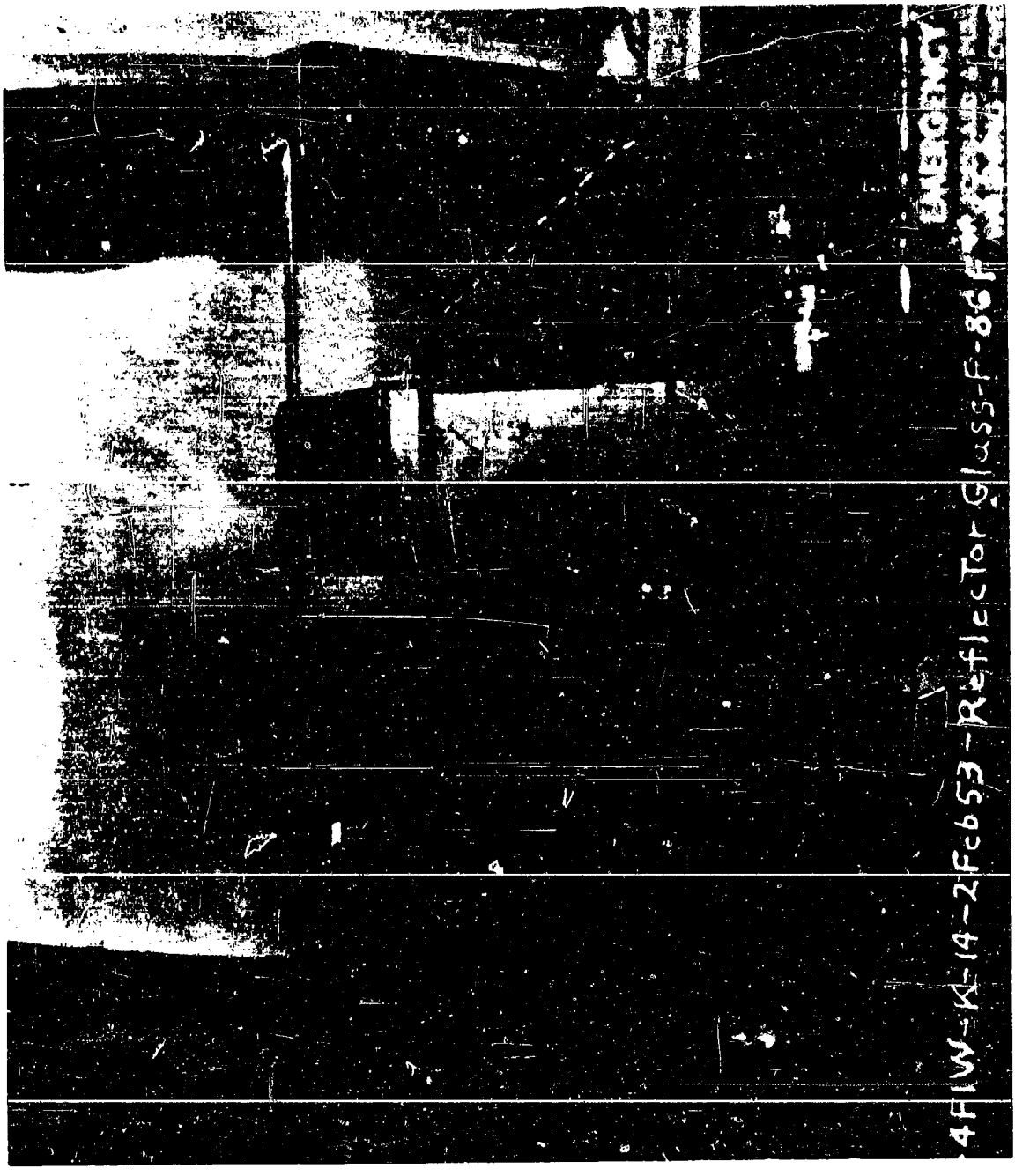


PHOTO #2

NAA CAMERA ERECTOR HEAD

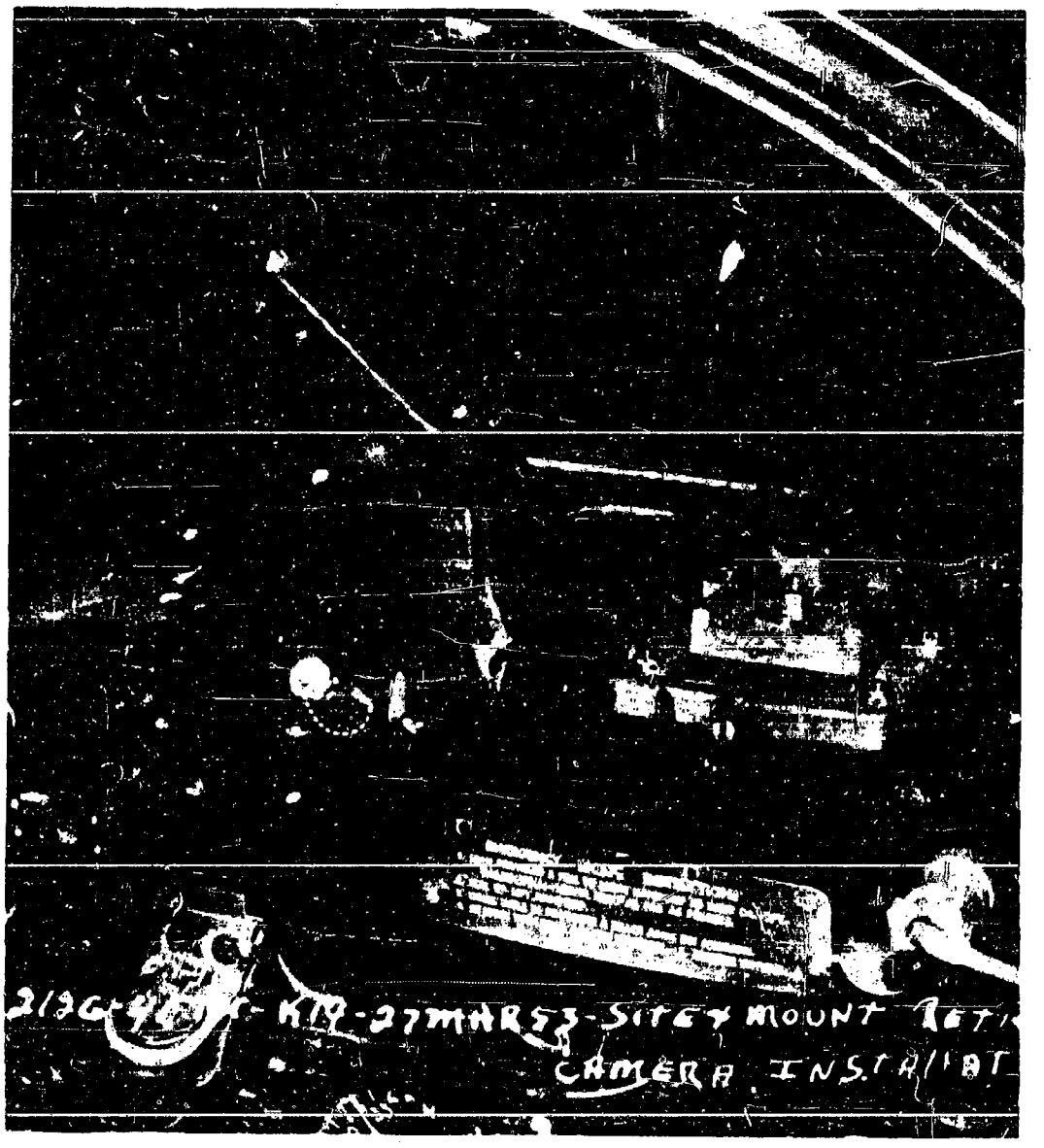


PHOTO #3

NEW ZOOMAR CAMERA ERECTOR HEAD

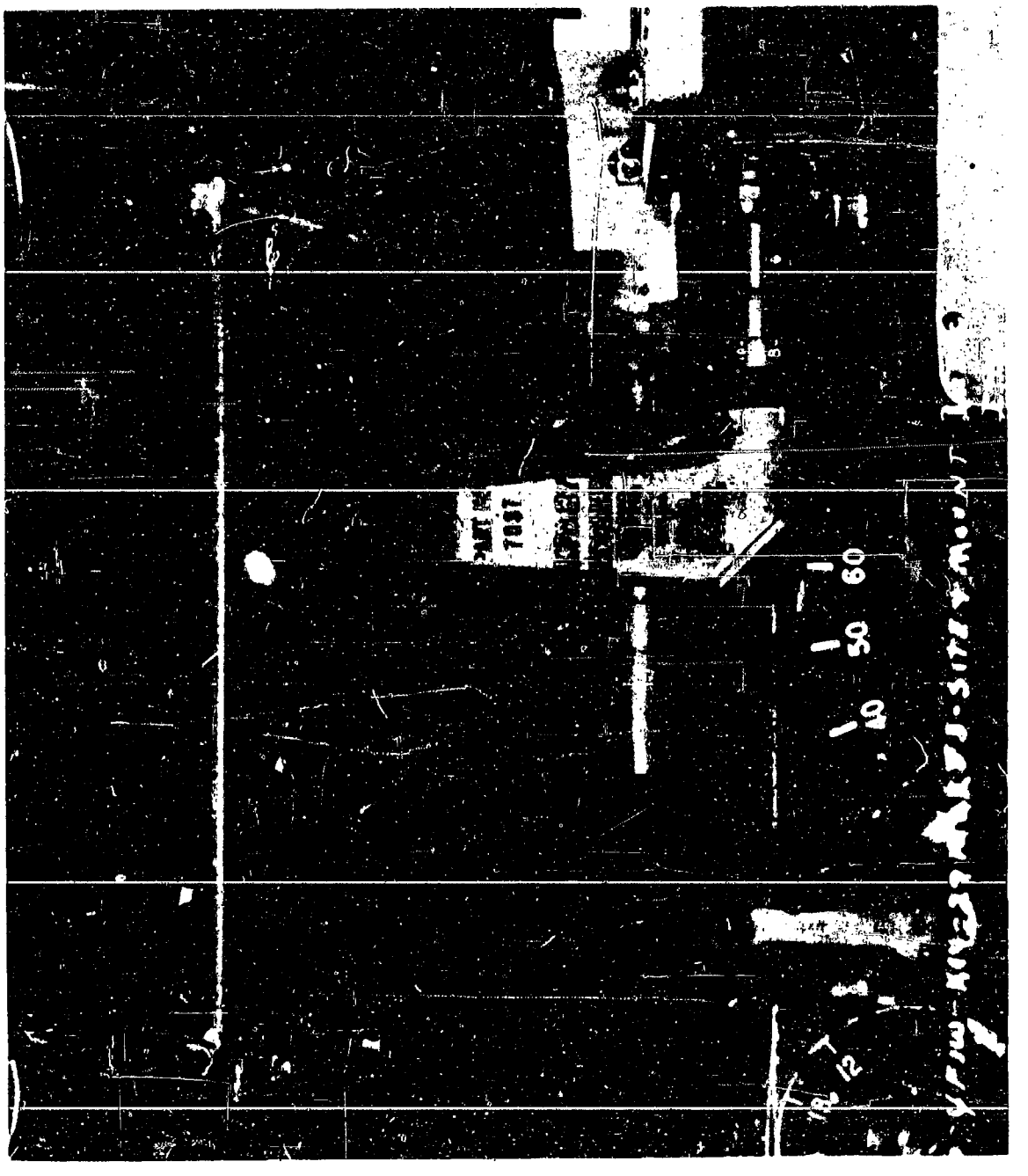


PHOTO #4

NEW ZOOMAR CAMERA ERECTOR HEAD

APPENDIX H

ENGINE COMPRESSOR STALL DATA

1. Occurrence

a. At frequent and unpredictable times while firing the guns above 35,000 feet during this test program, large flashes were observed forward of the gun muzzle. These flashes were of varying intensity and at times extended well forward in the vicinity of the air intake of the aircraft. On twenty occasions during this test program pilots reported an engine compressor stall accompanying the large flash. Early in the test one aircraft was lost with conditions associated with this engine compressor stall problem. Attached as Inclosure 1 are pictures taken during gun gas firing tests from an accompanying aircraft which show the build up of gun gas flash forward of the aircraft.

b. Conditions

Conditions under which these compressor stalls were encountered were at altitudes between 37,000 feet and 40,000 feet, at air speeds between .68 Mach and .96 Mach, engine conditions from 90% RPM to 99% RPM, tail pipe temperatures from between 500 degrees and 690 degrees and with HEI, API, and mixed loads of API and HEI ammunition. Complete data recorded on flights where engine compressor stalls were experienced is included as Inclosure 2.

The pilot's indication of engine compressor stall was: With the accompanying flash forward of the aircraft, he normally experienced an engine noise, best described as a pulsating effect, accompanied by a rapid increase in tail pipe temperature and a decrease in engine RPM. After investigation it was found that this condition could be corrected by moving the power control to the idle position and immediately diving the aircraft, increasing the ram air intake and seeking an atmosphere of higher density. After the third engine compressor stall, only experienced pilots were utilized in this test to minimize the possibility of losing another aircraft.

2. Effect on Test Program

After the third engine compressor stall associated with the armament installation, the aircraft were withdrawn from combat missions, and a series of gun gas test missions were flown in a non-combat area in the proximity of an airfield. During these tests photographs of

the associated gun gas flash were obtained. To find a condition which was suitable to recommit the aircraft to combat use, modification to the gun firing circuit was made which permitted the pilot to select firing of either the two upper guns or all guns. After firing 55 gun gas test missions, a decision was made to recommit the aircraft to combat use with the following restriction.

a. Four guns would be fired up to an altitude of 35,000 feet.

b. Two guns would be fired between 35,000 feet and 40,000 feet.

c. The guns would not be fired above 40,000 feet.

Since only experienced pilots were flying the test aircraft, and the frequency of compressor stalls could not be predicted, gun operation was extended to higher altitude when no enemy aircraft were encountered between 35000 and 40000 feet. There were six cases where pilots firing at enemy aircraft experienced engine compressor stalls. These were all above 40,000 feet. However, the pilot in each case was able to recover from the engine compressor stall and return safely. In one case, due to the severity of the engine stall condition, an engine was changed upon return to the home station. The occurrence of engine compressor stall associated with the armament installation caused considerable compromise to the test program. Therefore, the results attained in enemy contacts and those achieved on the occasions of enemy contact should be viewed with this in mind.

3. Investigation and Corrective Action Taken

a. The Gun Val project team in FEAF reported a decision to remove the test aircraft from combat because compressor stalls had been encountered three times on combat missions. The Gun Val committee immediately began an investigation to obtain a positive fix for such compressor stalls. Such corrective action would allow recommitment of test aircraft to unlimited combat and would avoid similar trouble in future production aircraft utilizing the T-160 gun.

b. At the request of the Gun Val Committee, the Ordnance Corps conducted tests to determine if API ammunition, deliberately mutilated, could cause pre-ignition of the ammunition in the vicinity of the muzzle of the gun. The results of these tests proved that it was virtually impossible for a round, that was capable of being automatically fed into the gun, caused premature ignition immediately forward of the muzzle of the gun.

c. Tests were flown with the two F-86F/T-160 aircraft of the same configuration as the FEAF test aircraft at Eglin Air Force Base and by North American Aviation, Inc., under the conditions described by the FEAF reports, but flashes of the magnitude experienced in FEAF or compressor stalls could not be produced with ball ammunition in approximately 28 missions flown expressly for this purpose.

d. In order to deliberately produce compressor stalls at will for controlled test on possible fixes, the Ordnance Corps produced 5,000 rounds of ball ammunition with the flash inhibiter removed. North American Aviation, Inc. requested to conduct flight tests under the following conditions.

(1) To determine the amount of uninhibited ammunition necessary to produce a positive stall at will.

(2) Test North American fuel rescheduling fix for capabilities to eliminate stall.

(3) Test both North American and Ordnance Corps finger type flash hiders for elimination of stalls by suppressing the flash.

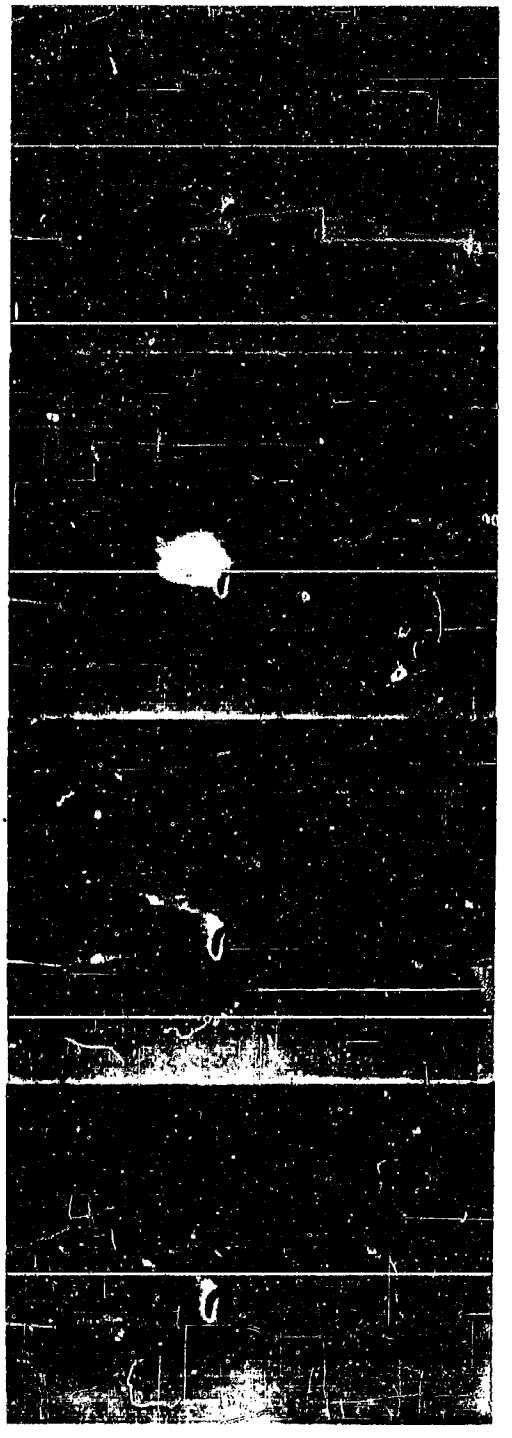
(4) Test Horseshoe shape blast deflectors to eliminate stalls by deflecting the gas away from the air intake.

e. An ammunition load of 60 rounds of ball ammunition followed by 15 rounds of uninhibited ammunition produced flashes of sufficient magnitude to cause compressor stalls on five successive attempts. Approximately 8 missions were conducted by North American with this load of ammunition incorporating the fuel rescheduling fix which proved to be successful in eliminating stalls in five out of seven instances. The next six missions incorporated the North American flash hiders which resulted in two stalls encountered in six missions.

f. The flash deflectors were welded to the normal blast panels at a distance slightly forward of the muzzle and in line with the bore of each gun and served to direct the blast away from the nose intake. Five flights were conducted at 41,000 feet with no stalls experienced on any of these flights. The pilot reported that the path of the flash during firing was noticed to be well to each side of the aircraft away from the intake duct. As a result of these tests, North American was given the go-ahead to fabricate sufficient kits to take care of the aircraft in FEAF. Blast panels with the blast deflectors installed were incorporated on three of the aircraft in FEAF. During the first seven flights on these aircraft, four compressor stalls and one flame out were experienced. The conditions of flight were at altitudes between 43,000 and 48,000 feet. A complete list of the flight conditions during these flights is included in Inclosure 2.

g. It was concluded as a result of the above mentioned flights that none of the fixes as described above were successful in eliminating the problems associated with the engine compressor stall difficulty. At the completion of the test program in Korea, it was concluded that the F-86F/T-160 installation was not suitable for combat use due to this problem.

h. The phenomenon associated with this problem, although not fully understood, has produced, through efforts to solve the problem, an understanding which provides a good basis from which to proceed with other aircraft installations scheduled to carry this new weapon.



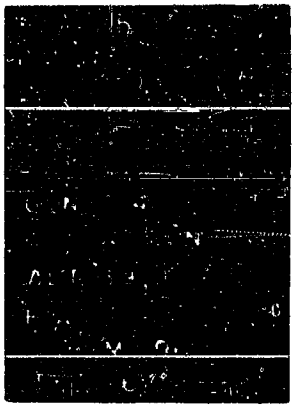
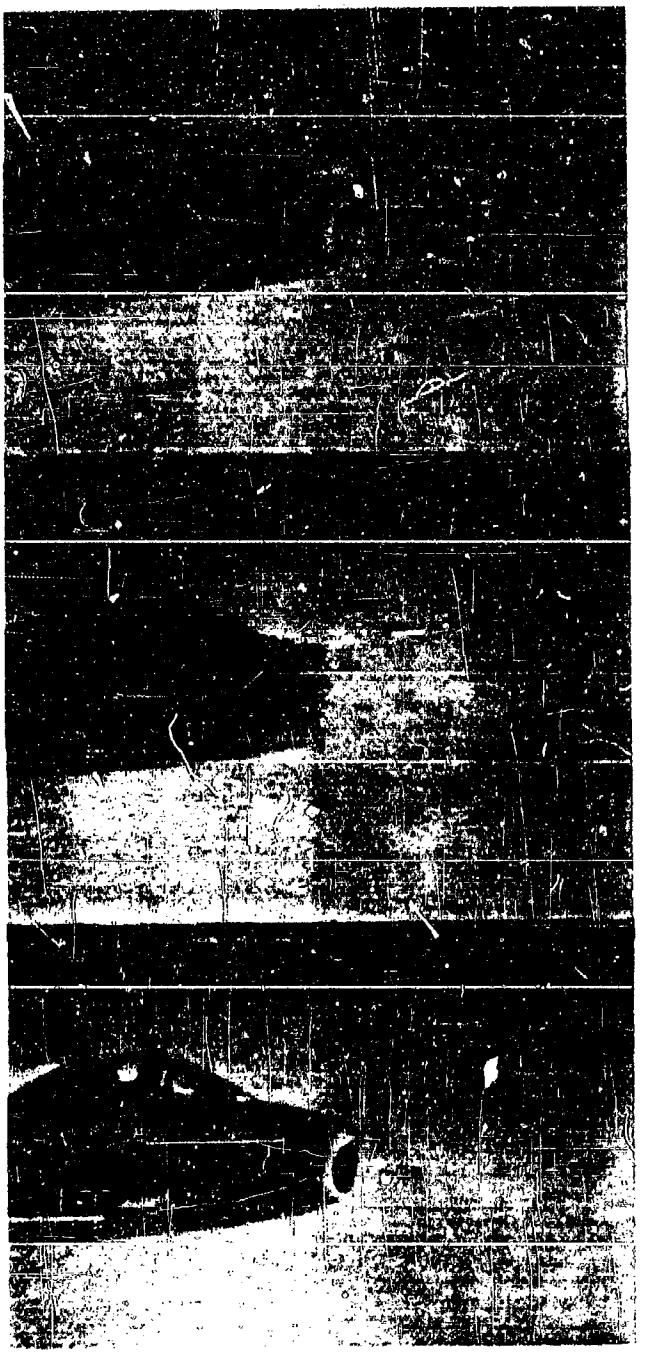


PHOTO #1



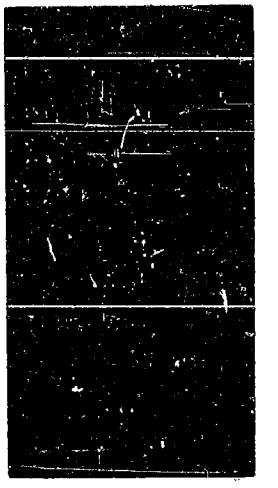
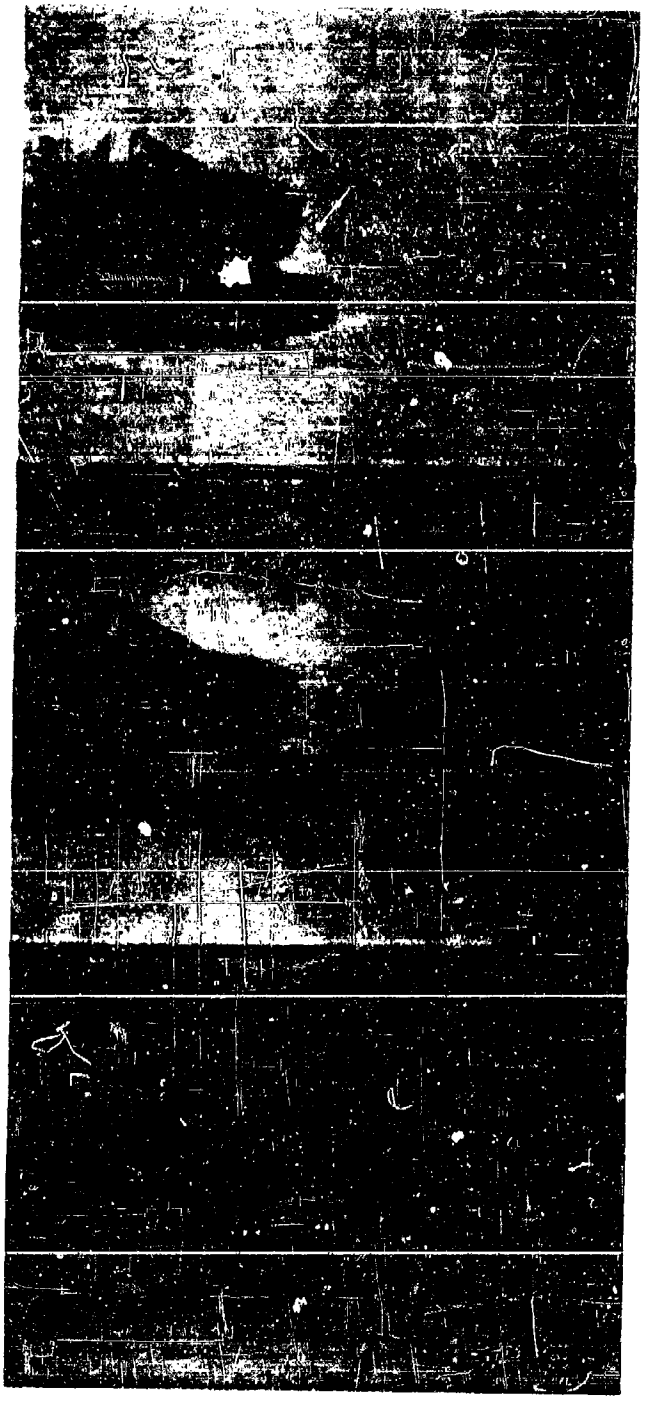


PHOTO #2



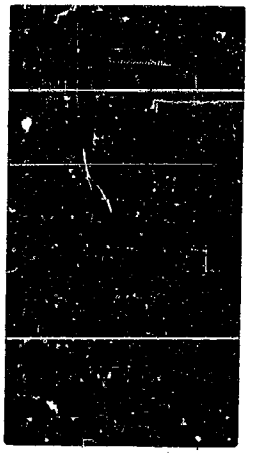


PHOTO #3

COMPRESSOR STALL CONDITIONS

	No. Guns	Type Ammo	Altitude	IAS (kts)	% RPM	TPT	Type Mission
1.	4	API & HEI	46,000	175	99	---	Combat Msn #10 - Firing on a Mig.
2.	4	"	37,000	250-260	96	---	Combat Msn #20 - Test fire on return - A/C lost.
3.	4	"	42,000	205	92	510	Combat #23 - Test fire on return
4.	4	"	40,000	205	98	670	Gun Gas Test Msn #24
5.	4	HEI	30,000	210	90	500	Gun Gas Test Msn #25
6.	4	API & HEI	45,500	225	94	625	Gun Gas Test Msn #36
7.	2	API	45,000	190	96	625	Gun Gas Test Msn #38
8.	2	API & HEI	41,000	.96 Mach	Full Power	---	Combat Msn #106 - Firing on a Mig.
9.	2	"	45,000	220	"	690	Combat Msn #113 - Firing on a Mig.
10.	4	"	37,000	210	92	510	Combat Msn #83 - Test fire on return
11.	4	"	47,000	150	Full Power	---	Combat Msn #159 - Firing on a Mig
12.	4	"	42,000	220	"	---	Combat Msn #173 - Firing on a Mig.
13.	4	"	41,500	---	90	520	Combat Msn #265 - Test fire on return.
14.	4	"	42,000	200 Mach	98	690	Combat Msn #275 - Test fire on return.
15.	4	API	46,000	190	97.5	690	Deflector Msn
16.	4	"	48,000	190	97	690	" "

	No. Guns	Type Ammo	Altitude	IAS (kts)	% RPM	TPT	Type Mission
17.	4	API & HEI	45,000	190	97.6	690	Deflector Msn
18.	4	"	43,000	190	97.6	690	" "
19.	4	"	42,000	190	97.5	690	" "
20.	4	"	44,000	150	99	690	Combat Msn #151 - Firing on a Mig.
21.	4	HEI	47,000	190	97.5	690	Flame Out.

APPENDIX I

SUGGESTED

TRAINING SYLLABUS

GUN AUTOMATIC - 20 MM (T-160)

TIME SCHEDULE

PHASE I	1 HOUR
PHASE II	24 HOURS
PHASE III	10 HOURS
PHASE IV	28 HOURS
TOTAL	63 HOURS

PHASE I

1.	History, description and principles of operation	30 Minutes
2.	General Data	30 Minutes
	Total	1 Hour

PHASE II

1.	Nomenclature	1 Hour
2.	Disassembly and assembly of gun	12 Hours
3.	Function of parts	6 Hours
4.	Preparation for firing and clearing gun	30 Minutes
5.	Malfunctions and Stoppages	1 Hour
6.	Cleaning and lubrication	30 Minutes
7.	Inspection and maintenance	1 Hour
8.	Review and examination	2 Hours
	Total	24 Hours

PHASE III

1.	Fundamentals of electricity	8 Hours
	a. Review basic electricity	
	b. Transformers and rectifiers	
	c. Capacitors and resistors	
	d. Circuit breakers and relays	
	e. AC-DC Circuits	
2.	Trouble shooting electrical circuits	1 Hour

a. AC Circuits

b. DC Circuits

3.	Review and examination	1 Hour
	Total	10 Hours

PHASE IV

1.	Ammunition: Description, Belting and Loading	1 Hour
2.	Malfunction range	6 Hours
3.	Aircraft Installation	1 Hour
4.	Practical work on flight line	6 Hours
5.	Harmonization	12 Hours
6.	General Discussion and review	1 Hour
7.	Final Examination	1 Hour
	Total	28 Hours

The foregoing syllabus covering a sixty-three (63) hour course of instruction is a supplement to the formal course of instruction for student weapons mechanics and on-the-job training for supervisors and senior weapons mechanics.

This course is based on the simplicity of the gas operated, revolver type gun and the introduction of an AC-DC firing circuit in the aircraft.

Special emphasis should be placed on a thorough course in electricity because most weapons mechanics are unable to trouble shoot the armament electrical system in modern fighter type aircraft.

The above listed syllabus was composed by personnel from ATRC participating in the project team.

APPENDIX J

ANALYSIS OF GUN VAL PILOT SUMMARY REPORTS

1. The following analysis resulted from a study of the Individual Pilot Summary Report (see Inclosure 1) submitted by twenty-six of the thirty pilots who participated in the test (these 26 pilot reports included as Inclosure 2). Written reports were not submitted by four pilots because of transfers to the ZI before the test was completed. These four pilots flew only one mission each, consequently it was not felt necessary to obtain written reports from them.

2. It must be noted that the experience level of all the pilots participating in the test was high, as indicated in Part I of the Individual Pilot Summary Report, when compared with present Air Force Standards. This was considered necessary for two reasons: First, to enable the pilot to intelligently compare this installation with other types he had flown; and second, to provide the most experienced pilots in the event of a compressor stall while firing this installation at high altitudes.

3. The following results were obtained from the Individual Pilot Summary Reports.

a. Aircraft Performance

Three of the pilots reported no apparent penalty in performance while flying the Gun Val aircraft in comparison with the .50 caliber installation in the F-86F. Twenty pilots stated that there was a slight penalty in performance in the Gun Val aircraft. Nine of the latter specifically pointed out that this penalty was observed only at extreme altitudes. In addition, two made no comment.

b. Length of Fire (4½ Seconds)

Seven of the pilots considered this time of fire acceptable for the present mission in "Mig Alley". Eighteen of the pilots considered this length of fire unacceptable even for this type of combat. Recommendations for increased time of fire are as follows:

(1) Eleven pilots desired 6 to 8 seconds of fire.

(2) Nine pilots desired 9 to 10 seconds of fire.

(3) One pilot desired 15 seconds of fire.

(4) Four pilots did not make any recommendation.

c. 3° Depression of the Guns

Eight pilots found this installation desirable. Three pilots found it undesirable, and eight pilots recommended gun depression but believed that 3° may be in excess. Six pilots made no comment due to lack of knowledge of the theory behind the 3° gun depression.

d. Requirement for Tracer Ammunition

The pilots were unanimous in their desire to have tracer ammunition during combat.

e. Terminal Effectiveness of the T-160 over the .50 Caliber Installation

Twenty-three pilots found the 20 mm to be superior to the .50 caliber installation. Two pilots made no comment.

f. Number of Guns for an Aircraft Installation

Twenty-three pilots considered four guns an adequate installation for future aircraft. Fifteen pilots voiced their opinion that no fewer than four guns should be in future installations. The remainder of the pilots had no comment relative to the number of guns.

g. Requirement for Selective Firing in a Four Gun Installation

Eighteen pilots desired a toggle switch arrangement to be able to fire either two or four guns. Five pilots found this undesirable, and two pilots made no comment.

h. Alteration of Tactics in the Present Air War in "Mig Alley"

One pilot stated that a change in tactics was required. Seventeen pilots stated that no change was required while flying this installation in the present air combat. Seven stated that minor changes were necessary in this installation in combat.

i. Requirement for Range Limiter

Eighteen pilots found this desirable. Four pilots found it undesirable and three pilots made no comment.

j. Requirement of In-Range Indicator

Nineteen pilots found this desirable, one pilot found it undesirable and five pilots made no comment.

k. Requirement for Sight Reticle Camera Installation of the Zoomar Variety

Twelve pilots found this desirable, nine pilots found the installation acceptable. By the word "acceptable", the latter pilots have realized the need for the sight reticle camera installation, however, they believe that more engineering is required to make the installation less objectionable from the standpoint of visibility. One pilot found it unacceptable, and three pilots made no comment.

l. Requirement for Lock-on Sensitivity Control in the Cockpit

Sixteen pilots found this desirable, one found it undesirable and seven made no comment.

m. Requirement for 20 mm Weapon in Future Fighter Aircraft

(The pilot was given an opportunity to express himself on future installations relative to all types of targets.)

Twenty-two pilots desire 20 mm armament for future aircraft. One pilot objected to the increased weight necessitated by the 20 mm armament, and two pilots qualified their statements to include only against bomber targets as a requirement for 20 mm.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. Date

B. Pilot's name and rank

C. Date of Pilot Rating

D. Total Flying Time

E. Total Fighter Time

F. Combat hours World War II

1. Request total and in addition general breakdown of type of missions, such as counter air, interdiction, escort, etc.

G. Combat hours Korean Theater

1. Fighter Bomber

2. Counter Air

H. Claims

1. World War II

2. Korean Theater

I. Remarks (Experience as Armament Officer, Gunnery Officer, etc.)

Part II - Gun Val Combat Experience

A. Total Missions

B. Number of engagements

C. Number of firing passes on enemy aircraft

D. Claims

PART III - Pilot's Comments (To be answered in narrative form)

A. Aircraft Performance

Is there a penalty in performance on the Gun Val aircraft as compared to a normal F-86 with the .50 caliber installation (climb, speed, ceiling, maneuverability, deceleration during gun fire)?

B. Length of Fire

In your opinion is the present installation with four and one half seconds of fire adequate for the type of combat experienced during this test? If not, please make a comment on the desired length of fire for future installations.

C. Tracers

Please make a comment as to the desirability of having a tracer round for this weapon.

D. Gun Depression

Do you find the 3^{0} depression of the guns desirable or undesirable? Why?

E. Terminal Effectiveness

Based on your own hits or others you have seen, make a comparison of the effect of hits with the 20 mm installation as compared with .50 caliber hits observed in past experience.

F. Number of Guns

1. In your opinion is the present installation of four guns adequate? Would fewer guns with more ammunition be more desirable?

2. Would you desire a selector switch in a four gun installation to allow you to fire two or four guns?

G. Tactics

In your opinion does this installation (i.e., shorter time of flight, HEI round, higher cyclic rate, four and one half seconds of fire, discharging spent cases, aircraft deceleration at time of fire and the 3^{0} depression of the guns) alter the tactics now being used by standard F-86F's?

H. Range Limiter

1. Do you find the range limiter, which stabilizes the sight at long ranges, a desirable feature on these aircraft?

2. Do you find the in-range indicator portion of the range limiter a desirable feature?

I. Sight Reticle Camera Installation

Did you experience any difficulty in visibility or tracking with the Gun Val camera installation on the sight?

J. Lock-on Sensitivity Control

Was the lock-on sensitivity control used during this mission?

K. Additional Comments

L. In view of above comments, how do you feel about the desirability of the 20 mm in future fighter installations?

LIST OF PILOTS WHO SUBMITTED WRITTEN GUN VAL SUMMARY REPORTS

1. Major Wendell D. Brady
2. Major Raymond E. Evans
3. Captain Manuel J. Fernandez
4. Major Vermont Garrison
5. Colonel James K. Johnson
6. Captain Lonnie R. Moore
7. Lt. Col. Carroll B. McElroy
8. Major James Jabara
9. Lt. Col. Donald L. Rodewald
10. Lt. Col. Clayton L. Peterson
11. Major Jack E. Mass
12. Captain David T. Davidson
13. Major Foster L. Smith
14. Lt. Col. Frank J. Keller
15. Lt. Col. J. R. Best
16. Captain Vincent E. Stacy
17. Captain Clyde A. Curtin
18. Captain Houston N. Tuel
19. Captain R. T. Dewey
20. Lt. Col. Philip E. Joyal
21. Captain William H. Champion
22. Captain Peter J. Fredricks
23. Captain Robert A. Windoffer
24. Captain Murray A. Winslow
25. Colonel George L. Jones
26. Colonel Royal N. Baker - Summary Report not received nor included with analysis.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background,

A. 23 April 1953

B. Major Wendell D. Brady

C. Date of Pilot Rating: 4 January 1943

D. Total Flying Time: Approximately 2700 hours.

E. Total Fighter Time: Approximately 1500 to 1600 hours.

F. World War II Combat hours: 189 hours.

1. Fifteen missions were bomber escort and the majority of the rest were counter air and interdiction, such as armed reconnaissance and specific counter air targets.

G. Combat hours in Korea: 43 combat missions, all of which have been some form of counter air, such as RF escort, fighter bomber escort and strictly combat air patrol.

H. Claims:

1. World War II: One ME-109 destroyed.

2. Korean Theater: None, as yet.

I. In World War II I was Squadron Gunnery Officer for the 513th Fighter Bomber Squadron, and since that time I have taught ground school for approximately one year in the USAF Gunnery school. I was the Operations Officer for the USAF Gunnery school for approximately one year and commanded a squadron in the Combat Crew Training Program at Nellis AFB, Nevada.

PART II - Gun Val Combat Experience

A. A total of six missions.

B. Five engagements.

C. One firing pass was made on enemy aircraft.

D. No claims.

PART III - Pilot's Comments

A. The penalty in aircraft performance on the Gun Val installation with respect to climb, speed, ceiling, maneuverability, etc., is no greater than found in two standard .50 caliber installations with the exception that there is quite a bit of deceleration during gun fire due to the heavier caliber of guns.

B. In my opinion, the length of fire in the present installation of 4½ seconds is not adequate for the type of combat in which we are now engaged. The need for conserving your fire and possibly missing kills because of the necessity of this conservation are my reasons for desiring more duration of fire. For my own benefit, I would like to see approximately 9 seconds of fire as I think that amount would be adequate under the present circumstances. I do not feel that a full 17 or 18 seconds of fire is necessary.

C. In regards to tracer ammunition, I believe there is a real need for the development of a tracer round for this installation, if it is accepted as a standard item on a standard fighter. My reasons for this comment are my own personal opinions. There are so many compromises in our gun fire control systems that it is almost impossible to find a condition in combat that will give you the accuracy necessary for a sure kill on the opening burst. The pilot has to add correction to compensate for the compromises when he is not firing under conditions upon which the sight is based. There are so many variables that the control system would have to be enormous to take them all into consideration, and until such time as they can manufacture a fire control system that can take into consideration all factors, a tracer is definitely needed.

D. I find a gun depression is desirable for my own personal firing in the F-86 because of the flight characteristics of the aircraft. I do not like the full 3° gun depression as well as I would like something approximately half of that, the reason being that the guns can be harmonized with the sight at an air speed at which a ground target can be attacked with reasonable accurate fire without causing a definite spiral course (over or under) as you approach the target.

E. In regards to terminal effectiveness, I have seen only one kill with the Gun Val installation, and in this instance I believe that 62 rounds per gun were the total rounds expended

for the kill. It is my personal opinion that a full two-thirds of that fire power was wasted. It is much more effective for the same length of bursts than the six .50 caliber installation.

F. The number of guns seem entirely adequate in my opinion. I would not like to see the number of guns reduced just for more ammunition. It would be much more desirable to keep the four gun installation with a selection system for the pilot to select either two or four guns.

G. All in all, I do not believe that the tactics had to be altered for use of Gun Val aircraft in the present combat situation. The Gun Val aircraft fit into the organization to which they were assigned, and the only consideration that had to be given them is the fact that they out-perform a large number of the aircraft organic to the squadron due to the extended leading edges. I would say this was to the advantage of Gun Val.

H. As to the range limiter on the Gun Val aircraft, I find that I can use it very effectively; however, I do not think it is necessary in that the sight can be stabilized by a mere movement of one finger, without a range limiter. As long as the range limiter is installed, it is my opinion that the in-range indicator portion will have to be a part of the installation to prevent the pilot from having to outguess the sight which would in effect be worse than having a fixed sight.

I. The sight reticle camera installation is very good. I did not experience any difficulty in tracking a target with this installation and the gun sight reticle superimposed on the gun camera film can be used to advantage in assessing a pilot's combat film for smooth tracking and determining when a sight is out of calibration.

J. I found the lock-on sensitivity control a big improvement on the sight, in that minor adjustments of the sensitivity of the radar could be accomplished by the pilot after he had taken off. In the event that it is not installed, these malfunctions will cause the pilot to revert to the manual range function of the sight when all is needed is a very minor adjustment on the radar. I believe that it has saved a lot of malfunctions of the radar system of the sight and it is well worth the weight spent in installing this in the gun fire control system.

K. The following remarks are opinions that I have formed over the past four years of working very close to the fighter game. It is my opinion that the fighter has to go to a heavy armament if he expects to knock down an airplane such as a B-36 or an atom bomb carrier. If not this 20 mm, some acceptable weapon that has the capabilities of knocking down an aircraft with a relatively few number of hits for the total time of fire. As speeds increase the pilot's aim wander increases which enables him to get fewer hits for a given size of target. I do not believe that fighter armament should be determined by what would be best for this particular situation in Korea. I say this because I believe the present six .50 caliber installation is entirely adequate to shoot down Migs where I do not think it is adequate to shoot down something like a IL-28 or even a TU-2. I think the concept of the use of air power has to be taken into consideration when you determine the armament for a fighter. If you are never going to be called on to shoot at an aircraft any larger than a Mig, then I do not believe that a gun heavier than the .50 caliber is necessary. If you are going to be called on to stop a heavier aircraft, I definitely believe that heavier armament is needed. It has to be heavy enough so that you can expect to shoot the target down in one firing pass. In other words, I want a heavier punch, but I want more than one punch. (I don't want rockets until I can get a lot of rockets that are not fin stabilized that give such large launching factors.)

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 2 May 1953.

B. Major Raymond E. Evans.

C. Date of Pilot Rating: 21 April 1943.

D. Total Flying Time: 2463 hours.

E. Total Fighter Time: 1600 hours.

F. Combat hours World War II: 440 hours. An estimated 80% of this was ground support, 10% counter air and 10% escort.

G. Combat hours Korean Theater:

1. Fighter bomber: 7 missions - approximately 15 hours.

2. Counter air: 41 missions - approximately 70 hours.

H. Claims:

1. World War II - One Japanese Nick destroyed.

2. Korean Theater - Two Mig-15 type aircraft destroyed, one damaged.

I. Experience in the armament field has been as test officer on the A-1 gun sight for approximately one year and gunnery experience in testing F-86, F-84 and F-80 type aircraft while test officer at APGC. Project Officer, Gun Val Project.

PART II - Gun Val Combat Experience

A. A total of 38 missions were flown.

B. Fifteen enemy engagements.

C. Five firing passes on enemy aircraft.

D. Two Mig-15 type aircraft destroyed, one damaged.

PART III - Pilot's Comments

A. I found two areas of aircraft performance which, in my

opinion, were affected by the armament installation. These aircraft were flown on a few missions with other F-86F's with the .50 caliber installations, and my observations were that the difference in climb, speed and maneuverability were not noticeable. However, I do believe that there is perhaps some price paid in absolute ceiling of the aircraft. This penalty perhaps is no more than would be found in 2 or 3 production aircraft with 10 to 20 degrees difference in tail pipe temperature. The deceleration while firing the guns was noticeably much greater with the 20 mm than with the .50 caliber.

B. I do not feel that 4½ seconds of ammunition is adequate for the type combat experienced during this test nor will it be sufficient for use when the target is a bomber or in the air-to-ground role. I feel that 6 to 8 seconds of ammunition would be adequate and much more desirable. I make this statement because of the inherent inaccuracies in our fire control system which does not allow us the accuracy of each round hitting the target.

C. I feel that there is a requirement for tracer ammunition to be used in the type combat experienced in Korea. For long range firing where the target can be tracked for several seconds, I would not care for the use of tracers. However, there are many times during combat that the pilot only has a fleeting moment to fire, and I feel that tracers in this case may improve his effectiveness by his ability to rapidly ascertain whether he is on the target or slightly above, slightly below or slightly to one side.

D. I found the 3^0 gun depression desirable for the type of combat encountered. However, this is not meant to say that the 3^0 depression of the guns would be optimum for other conditions of combat. The 3 depression of the gun is desirable in this case, since the angle of attack of the aircraft at altitudes of 40,000 feet and above is roughly in the vicinity of 3^0. Perhaps in other aircraft 3^0 would not be the optimum gun depression. I firmly believe that a depression of the guns away from the flight reference line is a desirable feature.

E. The destructive capabilities of the 20 mm ammunition was many times greater than would be expected from the .50 caliber. Since most of the firing was at relatively high altitudes, above 40,000 feet, and with the present state of the gun camera capabilities, it was not possible to accurately assess damage to enemy aircraft with each hitting round. However, it is quite obvious that much more damage was being inflicted

with each round that hit the enemy target. While conducting the air-to-ground phase of this program against trucks and a tank and being able to assess the damage after the mission, I was quite impressed by the effectiveness of the HE ammunition against trucks.

F. I feel that the present number of four guns is adequate for future fighter aircraft. I do not feel that a fewer number of guns would be as desirable since this would reduce the density, i.e. installation cyclic rate, to a point where the hit probability would be reduced below an acceptable number.

G. In my opinion the high cyclic rate of the gun, shorter time of flight, discharging of spent cases have made no noticeable changes in tactics in utilization of the aircraft. However, the shorter duration of fire, 4½ seconds, and the fact that the aircraft definitely decelerates much more at time of fire does require the pilot to be ever conscious of attempting to get to a very close range before firing. This condition is accentuated by the lack of positive closure at high altitudes when flying against the Mig. I feel that the 3° depression of the guns has been an improvement in this case in that it does allow a reduction in the requirement for velocity jump since the guns are more nearly along the flight path. This 3° depression of the guns would seem optimum for the extreme high altitude conditions experienced here in the Korean situation. However, for a different aircraft a more suitable depression of the guns might be found, i.e. 2° or 2½°. I am firmly convinced that guns depressed from the flight path line is a desirable feature due to the frequent inability of the sight to provide the correct velocity jump.

H. I feel that the range limiter is a great asset to the A-4 fire control system. The increase in stability is quite noticeable when tracking at longer ranges. However, in most attacks, since the rate of closure is very small some of the advantages of this increased stability cannot be realized. I find the in-range indicator portion of the range limiter a very desirable feature.

I. I feel that the sight reticle camera installation which we had in the Gun Val aircraft was very desirable. The original installation which had an erector head that was 1½ inches in width did detract somewhat from the visibility of the pilot. However, when the new Zoomar erector heads were installed this annoyance was reduced greatly. I feel there is a definite

requirement that all fighter aircraft have a suitable method for recording the reticle image to be used in analysis of determining the actual conditions of flight when firing at enemy aircraft. This becomes extremely important if we are to find a suitable method of assessing our effectiveness.

J. I found the lock-on sensitivity control quite desirable. I feel that it affords the pilot a method of peaking his radar after he has become airborne and since the conditions under most flights that these aircraft were subjected to was at altitudes above 40,000 feet, this became quite important.

K. I feel that the most important characteristics about this new 20 mm weapon is its high cyclic rate of fire. By firing 6,000 rounds a minute from the installation we have a sufficient density to allow us a high hit probability which I feel more than compensates for the added weight of the installation. I feel that a selector switch in a four gun installation would not be advisable since oftentimes the pilot would be selecting two guns and in the urgency of the situation would forget to change to his four guns.

L. Although the 20 mm installation in the Gun Val aircraft has some definite disadvantages, I feel the most important assets are the high cyclic rate which will enhance the pilot's probability of hitting, and the destructive capabilities of the 20 mm HE round. I feel that the T-160 gun will provide us with a more effective armament system in our future fighters.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 27 April 1953

B. Captain Manuel J. Fernandez

C. Date of Pilot Rating: 20 November 1944

D. Total Flying Time: 3200 hours

E. Total Fighter Time: 1700 hours. 1200 hours in jet, 700 in F-86's. All gunnery or combat.

F. No World War II combat.

G. Combat hours Korea:

1. No fighter bomber missions.

2. 160 combat hours in counter air.

H. Claims

1. World War II - None

2. Korean Theater - 11 Migs destroyed; 2 damaged

I. Armament Officer at USAF gunnery school at Nellis AFB, Nevada, for a period of four months. Gunnery Officer for seven months here in the 334th Fighter-Interceptor Squadron. I was an F-86 Gunner Instructor at the USAF gunnery school at Nellis AFB, Nevada for two years in a flying capacity.

PART II - Gun Val combat experience.

A. Total Missions: 3

B. Number of Engagements: 1

C. Number of Firing Passes on enemy aircraft: 1

D. Claims: 0

PART III - Pilot's Comments

A. In reference to performance of the Gun Val aircraft as compared with the normal F-86, it was noticed that there is a slight loss in rate of climb, slightly lower than the normal F-86.

B. It is believed that the time of fire is adequate for this theater. Would desire approximately 15 seconds time of fire for sustained combat.

C. Tracers would be desirable.

D. I believe that there is too much gun depression for low altitude, high speed work.

E. I have not observed any hits with the 20 mm, other than film assessment.

F. I believe that four guns are adequate and do not desire a selector switch as I personally desire a heavy concentration of fire.

G. The installation in the Gun Val aircraft does not change the tactics in this theater; however, there is more deceleration in the Gun Val aircraft when firing than there is in the normal F-86.

H. The range limiter, I believe, is a fine installation for pilots with a small amount of experience or newly commissioned pilots, and the in-range portion of the range limiter aids the newer pilots in determining their ranges.

I. The sight reticle camera installation afforded no great difficulty in visibility in tracking with the camera installation on the sight.

J. I did not use the lock-on sensitivity control during my missions.

K. It is the belief of this individual that the 20 mm aircraft is a highly desirable feature to be used in future fighter installations due to the aircraft being stressed for higher speed and being built stronger for subsonic and supersonic work.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 21 April 1953

B. Major Vermont Garrison

C. Date of Pilot Rating: October 1941

D. Total Flying Time: 3,000 hours.

E. Total Fighter Time: 2800 hours.

F. World War II experience consisted of 250 hours, of which 89 missions were flown. 60% of the missions were escort missions and 40% of the missions were fighter sweeps. Occasional ground strafing was conducted upon return from the above missions.

G. Korean Combat Hours:

1. No fighter bomber hours.

2. 58 missions - 85 combat hours.

H. Claims:

1. World War II - 11 aircraft destroyed, approximately 8 or 10 locomotives destroyed and numerous air fields strafed.

2. Korean Claims: 3 Migs destroyed, 2 probably destroyed and two damaged.

I. I have been a gunnery officer for 10 years, a gunnery instructor and worked in research and development section for gunnery at Nellis Air Force Base for one year.

PART II - Gun Val Combat Experience

A. Number of Missions: Ten

B. Number of Engagements: Four

C. Number of firing passes at enemy aircraft: Two

D. Claims: One Mig destroyed, one probably destroyed.

PART II - Pilot's Comments

A. I have flown various types of fighters. I have about 700 hours in F-86's, about 700 hours in F-80's and around 50 to 100 hours in F-84's. I have approximately 500 hours in P-51's, about 500 hours in P-47's, around 150 hours in Hurricane fighters and about 50 hours in Spitfires.

I believe that we pay a penalty in performance on the Gun Val aircraft as compared to the F-86 installed with the .50 caliber. The climb is slightly less, the top speed is probably very close, the ceiling and maneuverability is a little less in the Gun Val aircraft and the deceleration during firing is noticeable as to be greater over the .50 caliber installation. However, firing the two types of aircraft side by side, this is not too noticeable.

B. In my opinion, the present installation with 4½ seconds of fire is not adequate for the type of combat that we are experiencing at the present; however, as to the desired length, I feel that somewhere around 6 to 8 seconds would be adequate.

C. I also feel that tracers would be very desirable in this weapon due to the fact that we have inaccuracies in the gun sight, which I feel make tracers necessary.

D. I feel that the 3 degrees depression of the guns is desirable. For one reason, during ground support, I feel that as against the .50 caliber harmonization it allows a pilot to fire closer to the target and does not fly the so-called pursuit curve on the ground that the old harmonization of the .50 caliber does. As to the desirability of the 3 degrees depression of the guns in aerial combat, I feel that it is equally as good as the .50 caliber harmonization and, in some cases, I think it is better.

E. In comparing the effectiveness of the 20 mm to the .50 caliber hits, in my opinion, there is no comparison at all, because I feel that the 20 mm is much more effective at any range and that you are able to hit the enemy aircraft.

F. In comparing the number of guns with the present installation of the .50 calibers, I feel that the four T-160 guns are adequate, and I personally would not like to have fewer guns. I would like more ammunition. I feel that if we cut down on the number of guns, we are cutting down considerably on the hit probability, and I feel that this is not desirable.

However, I would desire a selector switch personally due to the fact that there are probably going to be times when the pilot may feel that two guns would be adequate and having a selector switch will allow him to double his length of sustained fire if he so desires.

G. I do not feel that this installation alters the tactics being used by standard F-86's in any material way. Due to the short length of fire, however, I think it probably has the tendency to cause most of the pilots to be a little more conservative in their expenditure of ammunition. One thing that I think should be mentioned at this time and that is the fact that we have a possibility of a compressor stall at high altitudes while firing four guns. Of course, this is very undesirable and will have to be remedied by different installation in the aircraft. The short time of flight of the T-160, the HEI round, the higher cyclic rate are very desirable. The 4½ seconds of fire, I think is a little too short. I feel that 6 to 8 seconds would be more adequate. As to the discharging of spent cases, I do not feel that this materially affects the tactics in any way, because in general the wing man is never flying directly behind the aircraft that is firing.

H. I feel that the range limiter is a desirable feature. The in-range indicator portion of the range limiter in my opinion is also a desirable feature. It gives a very positive indication of the range, and in many cases I think it will help many pilots.

I. I feel that the sight reticle camera installation is desirable and after the modification I did not experience any difficulty in tracking with the Gun Val installation; however, the installation previous to the one now in use, in my opinion, was not desirable because it obstructed the pilot's vision.

J. The lock-on sensitivity control I feel is very desirable because it allows the pilot to have his radar operating properly and have some control over it in the cockpit, which he would not have without the lock-on sensitivity control.

K. I would like to add a few remarks here on the fact that I believe that many damaged aircraft that we have had using the .50 caliber installation would probably have turned into probables or kills using the 20 mm in the T-160 guns. This appears obvious to me in the few number

of hits it takes to knock down an enemy fighter in comparison to the number of .50 caliber hits.

L. I feel that it is very desirable to have the 20 mm T-160 guns in future fighter installations, not as they stand right now, but with the necessary modifications. I feel that we should have a better mount on the gun, which I think can be done and I do believe that we need tracers, and I also believe we need longer sustained fire. I feel that in most of the cases we would be able to sacrifice the small bit of performance that the extra weight will carry to guarantee more assurance of a kill.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 1 May 1953

B. Colonel James K. Johnson

C. Date of Pilot Rating: 30 August 1940. I have been on flying status ever since.

D. Total Flying Time: 3130 hours.

E. Total Fighter Time: 2000 hours.

F. Combat Hours World War II: 230 hours in P-47's.

1. A general breakdown of this 230 combat hours consisted of 92 missions of which approximately 60% were interdiction, 20% escort and 20% counter air.

G. Korean Combat Hours: 101 hours which is approximately 68 missions. All of these have been counter air.

H. Claims:

1. World War II: One FW-109 confirmed kill.

2. Korean Theater: 7½ kills, 3 probables and eight damaged. These are all confirmed with the exception of one damage.

I. My experience in the armament and gunnery field consists of a general knowledge that a normal commander would have of a group or wing.

PART II - Gun Val Combat Experience

A. Total Missions: Two.

B. Number of Engagements: One.

C. Number of firing bursts on enemy aircraft: Three. These three bursts expended my ammunition.

D. Claims: One Mig-15 type aircraft damaged.

PART III - Pilot's Comments

A. I believe the Gun Val aircraft is slightly more sluggish,

meaning that the turning radius is slightly more, speed is slightly less, the ceiling is less and I think when firing the T-160 guns that you, of course, do get more deceleration than with the .50 calibers. I think the main penalty that you pay with the Gun Val installation is the additional weight. I believe your optimum altitude is slightly lower than with other F-86's, and I think the turning radius is more.

B. The desired length of fire for our future aircraft is a most difficult question to answer. I would say, generally speaking, for a day fighter around 9 seconds would be the minimum that I would settle for. I would not settle for any less because of the basic inherent inaccuracies of the sight.

C. I think very definitely that the T-160 gun should have tracer type ammunition.

D. I think the 3 degree depression of the Gun Val aircraft is desirable because it is more in line with the flight path at high altitudes.

E. In regard to the terminal effectiveness of the T-160, I do not think there is any doubt that it is more destructive. However, in my own personal observations, I've only seen one hit.

F. No comment.

G. I do not believe the Gun Val installation would have any appreciable effect on tactics; however, I do believe that at 46,000 feet the Gun Val aircraft is not quite as fast as the 6 X 3 leading edge F-86F with .50 calibers. I believe the turning radius would be more.

H. In regard to the range limiter, I find it a very desirable piece of equipment or modification and should be incorporated on all day fighter interceptors. I find that the in-range indicator portion of the range limiter is also a very desirable feature.

I. I was not too much in favor of the original sight reticle camera installed on the Gun Val aircraft because of the width of the erector head. I believe this width was 1½". This 1½" I found did have an appreciable restriction on my forward view. With the recent installation of the 5/8" erector head, I find it desirable, and I recommend that it

be installed in all of our F-86's.

J. I think that the lock-on sensitivity control in the cockpit is a desirable feature in that it does give the pilot another control that he can adjust in the air. In my own case, I adjusted the sensitivity control at several altitudes, generally speaking around 10,000 or 12,000 feet and again at 20,000 and then at 30,000 and then at my maximum altitude which is generally 45,000 or 46,000 feet.

K. No comment.

L. For future day fighter aircraft, I think the Gun Val installation is a step backwards. I believe for the future fighter aircraft, we should stress a light weight, high performance, high altitude fighter. Consequently, I don't think that we should have more guns installed in our aircraft. I believe we should settle for four .50 calibers.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 30 April 1953

B. Captain Lonnie R. Moore

C. Date of Pilot Rating: 15 April 1944

D. Total Flying Time: 2830 hours

E. Total Fighter Time: 1235 hours

F. Combat hours World War II: 170 hours

1. 54 missions in the E.T.O. in B-26 type aircraft.

G. Combat hours Korea: 80 hours

1. 53 missions flown as interceptor sweeps.

H. Claims:

1. World War II: None

2. Korean Theater: 1½ destroyed, 1 probably destroyed.

I. While with the 14th Fighter Group, I had additional duties as squadron armament officer for a period of approximately 6 months. As test officer at Eglin Air Force Base, I was test officer on the A-1 CM gun sight in the F-86A type aircraft and test officer on the A-4 gun sight in the F-86E type aircraft. In addition to these two tests, other experience was from the two type gun sights on other tests when the gun sights were used on rocket and bomb functions.

PART II - Gun Val Combat Experience

A. Total Missions: 30

B. Number of Engagements: 19

C. Number of Firing Passes on Enemy Aircraft: 9

D. Claims: 1½ destroyed, 1 probably, and 1 damaged

PART III - Pilot's Comments

A. There may be some penalty in performance in the Gun Val

aircraft as compared to the normal F-86 with the .50 caliber installation as to climb, speed, ceiling, maneuverability, etc., but it was not too noticeable. It is my belief that this difference in weight and performance can be found if two production line F-86's were checked against each other. There is a greater deceleration during the firing of the T-160 guns while in flight than there is in the .50 caliber guns.

B. It is my opinion that 4½ seconds of fire is not adequate in the type of combat experience on this test. Although it would be undesirable to add additional length of fire by putting more ammunition in the present installation as the extra weight would not make it desirable. The pilot should have enough ammunition in combat to enable him not to be too conservative with the ammunition so that he can waste some and still have enough to destroy the target. It is my belief that 6 to 8 seconds of fire would be adequate.

C. In this type of warfare, tracers are very desirable. Tracer ammunition should be made for future use in the T-160 guns.

D. The 3° depression of the guns is desirable on this installation. It is my belief that pilots flying Gun Val aircraft were not subject to as much jet wash from enemy aircraft as pilots flying aircraft with .50 caliber installation, while flying in trail and shooting at a Mig.

E. The 20 mm ammunition is much more destructive than the .50 caliber especially the 20 mm with HE ammunition. This opinion is based on comparing both Gun Val film and film from .50 caliber installations.

F. Four guns seem to be adequate for 20 mm, as this gives enough fire power so that a reasonable amount of hits can be obtained on a given target. A selector switch to select 2 or 4 guns to fire is not necessary if the length of fire is increased to 6 to 8 seconds.

G. No change in tactics is necessary with the T-160 gun installation over what the present .50 caliber F-86's are now using.

H. The range limiter is definitely desirable as part of the fire control system as it lessens the sensitivity of the sight reticle, thereby making it easier to track the enemy

aircraft at extreme ranges and indicates to the pilot when he is in the proper range to fire. The in-range indicator portion of the range limiter is necessary and is a very desirable feature in that an indication is shown to the pilot when he has his selected range so that he will know his sight is computing properly, and is giving him a true indication of his range.

I. The Zoomar sight reticle camera extension does not hinder the pilot in tracking whatsoever. After a few missions using this type of camera installation, the erector head is no longer noticeable.

J. Almost on every mission the lock-on sensitivity control was used to increase the sensitivity of the radar so that a lock-on was obtained to noise and then the sensitivity was decreased until the lock-on light would go out. This is a very desirable feature in that the pilot is able to have some control of the sensitivity of the radar set during flight.

K. It is my belief that the Air Force needs 20 mm cannons in all future fighter installations rather than .50 caliber machine guns. It is my belief that a bomber would be more easily destroyed with 20 mm than with a smaller gun.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 22 April 1953

B. Lt. Col. Carroll B. McElroy

C. Date of Pilot Rating: 23 November 1943

D. Total Flying Time: 1550 hours

E. Total Fighter Time: 725 hours

F. Combat hours in World War II: 47 hours

1. 8 missions on escort and one dive bomber mission and 4 on a sweep.

G. Korean Air War: 180 counter air in F-86 type aircraft.

H. World War II Claims: None.

1. Korean: 2 Migs destroyed, 1 probably destroyed and one damaged.

I. No experience as gunnery or armament officer.

PART II - Gun Val Combat Experience

A. Total missions: 8

B. Number of Engagements: 2

C. Number of Firing passes on enemy aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. I feel that there is no penalty imposed on the performance on the Gun Val aircraft as compared to the normal F-86 with .50 caliber with the exception of the deceleration during firing. I feel that if you were just within range and started firing it would drop you back out of range. I did not experience this during my test so I do not know how valid the assumption is.

B. In my opinion, the present installation with 4½ seconds of fire is not adequate for this type of combat and the type missions experienced during this test. I would like to have a little bit more. I believe a minimum of 6 seconds of fire would be desirable.

C. As regards to tracers, I think it would be desirable to have tracers in this weapon. Tracers are needed because the sight itself when working perfectly has certain errors; the boresighting may take out these errors or add additional errors. I feel that with tracers you can ascertain to a better degree how much of an error you have, and therefore allow for it. Also, if the sight were to go out you could fire using tracers if you are within a very close range.

D. On the 3^0 depression of the guns, having never fired at an enemy aircraft, I do not know how valuable my assumption is, but I feel that with the 3^0 gun depression that you will have the advantage of not having to turn the square corner when you are tracking and coming in close. I also feel that in certain instances it would keep you out of the jet wash of the enemy aircraft.

E. On the terminal effectiveness of the 20 mm installation I think there is no comparison at all between the two. In the hits I have seen made by the 20 mm, they completely destroyed the target. I feel that if we had gotten the hits that you sometimes see in the .50 caliber film with a 20 mm weapon out probables or damages would be destroyed.

F. I feel that the present installation of four guns is adequate, and I do not think that fewer guns with more ammunition would be desirable. I do think the selector switch for four guns is a good idea. I feel that the switch should be located so that you could switch from two to four and four to two without moving your hand from the throttle.

G. As regards to the tactics with the 20 mm, I don't feel that there is any difference in the tactics, and I feel that the short time of fire and the deceleration is a disadvantage; however, by firing short bursts the deceleration would not be as noticeable as if you were to continue firing long bursts.

H. The range limiter is very desirable in that it stabilizes the sight at long ranges, and I think it is a desirable

feature in all fighter aircraft. I find that the in-range indicator portion of the range limiter is also very desirable.

I. The sight reticle camera installation causes no difficulty in tracking. For the first few missions it appeared to be in your way; I think you could get accustomed to it very easily.

J. The lock-on sensitivity control was used on these missions, and I think it is desirable in that you have it in the cockpit so that you can adjust it in flight and get the best use of it.

K. I am very much in favor of the 20 mm in future fighter installations. I think if they do find a fix for the problem encountered it will be the answer to our fighter aircraft armament.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 28 April 1953

B. Major James Jabara

C. Date of Pilot Rating: 1 October 1943

D. Total Flying Time: 2750 hours

E. Total Fighter Time: 1750 hours

F. Combat hours World War II: 415 hours

Fighter bomber, escort and counter air.

G. Combat hours Korea: Counter air 175 hours

H. Claims:

1. World War II: 9½ airplanes destroyed

2. Korea: 6 Mig-15 type aircraft destroyed.

PART II - Gun Val Combat experience

A. Total Missions: 6

B. Number of Engagements: 4

C. Number of Firing passes on enemy Aircraft: 1

D. Claims: 0

PART III - Pilot's Comments.

A. The aircraft appears to me to be a little more sluggish and does not have the performance the other F-86 aircraft equipped with the .50 caliber installation, especially at high fuel loadings and high altitudes. However, at the lower altitudes, performance appeared about the same. Maximum performance is, of course, highly desired and critical at the higher altitudes. But the difference is slight.

B. I think the present 4½ seconds of fire is the bare minimum with this type armament. I would personally like to see about 8 seconds of firing time available to the pilot; however, this 8 seconds of firing time must be compromised with any loss in aircraft performance due to the additional weight 8 seconds of firing time would add to an airplane.

C. I would like very much to have a tracer round on this equipment as it gives me some idea whether my armament system is operating as it should. I find tracer is helpful in firing at aircraft inasmuch as most of the firing is done from the astern position of the enemy aircraft.

D. I find that the 3° depression of the guns is desirable because it allows the pilot to pull higher G's immediately upon initiating an attack and also permits more effective tracking.

E. I have not hit an airplane with this equipment; however, based upon ground tests that I have seen and the little film that I have seen, I personally would trade one hit with this type ammunition to 10 hits with the present .50 caliber type ammunition.

F. I think the present installation of four guns is adequate. I would not like fewer guns because I want all the punch I can get when and if I get into range and fire on another aircraft. I would rather chance running out of ammunition with the four guns than to have fewer than four guns. This punch I speak about is the reason why I am all for the 20 mm gun. I would like a selector switch, however, in order to fire either two or four guns, especially at long ranges where I might go ahead and shoot with two guns.

G. I do not feel that the tactics are altered as the basic problem of shooting down an aircraft is to get in a shooting position or in the stern position. None of these factors, in my opinion, are changed by this new equipment. It might, however, require more skill and discipline on the part of our pilots in order to conserve ammunition and fire at only the closest possible ranges in any engagement. I think ammunition discipline would have to be stressed and utilized at all times.

H. I like the range limiter very much. I find that the in-range indicator position of the range limiter helps me estimate ranges much better, and without a doubt, would

help me also to save ammunition. I think the range limiter is a very desirable installation.

I. I've experienced no difficulty in visibility or tracking with the Gun Val aircraft camera installation on the sight.

J. The lock-on sensitivity control was used during all of my flights, and I like it very much. There were times, however, when lock-on was not effected due to internal disturbances in the aircraft.

K. I feel that if we had had this equipment previously our kill ratio to the probable kill and damaged aircraft would be upped considerably because of more punch which this equipment carries over the present equipment now used. Because of the peculiarities of jet warfare and the high speeds involved, we must take advantage immediately and instantly of any firing opportunity afforded us. That firing opportunity must be exploited immediately with more punch. I think this equipment gives us that added punch. That is why I would like to see the equipment further researched and developed and put in our future day fighter aircraft.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 2 May 1953

B. Lt. Col. Donald L. Rodewald

C. Date of Pilot Rating: 31 August 1943

D. Total Flying Time: 4036 hours

E. Total Fighter Time: 1400 hours

F. Combat hours World War II: 21 hours

G. Combat hours Korea: 43 hours - 27 missions

H. Claims:

1. World War II: 5 Junks, 12 - 13 railroad cars and numerous anti-aircraft installations. Fighter-bomber type missions.

2. Korean Theater: One Mig-15 probably destroyed.

I. Gunnery Officer since 1943 and armorer and armament officer for the past 14 years.

PART II - Gun Val Combat Experience

A. Total Missions: 15

B. Number of Engagements: 8

C. Number of Firing passes on enemy aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. There appears to be a slight penalty in performance on the Gun Val aircraft, noticeable only above 40,000 feet. I have not flown the caliber .50 installation with the straight leading edge; however, this installation does appear from comparison on missions to have a ceiling slightly less than the caliber .50 equipped F-86F with straight leading edge.

There is a definite deceleration on this aircraft during gun fire, and it appears to the pilot to be in excess of the normal F-86 with the caliber .50 installation. It is not noticeable during short bursts, but for a burst longer than one second it is very noticeable and especially if fired in formation with another aircraft flying line abreast.

B. In my opinion 6½ seconds of fire is adequate for the type of mission being flown in "Mig Alley" at the present time. However, it does not leave any cushion to take care of the unexpected. Therefore, I would call this unsatisfactory for a production installation. I would highly recommend a minimum of 8 seconds of fire for a production installation. If we were in a position in combat in this theater where we had to fight our way home or the missions were such that we could expect more contacts with the enemy, the present 6½ seconds would be entirely inadequate.

C. I believe it would be desirable to have a tracer round manufactured for this weapon; however, I caution that a tracer must be used in an intelligent manner and not as a sighting aid in other than evasive action type of firing or in the event of failure of the gun sight. If the gun sight is operating properly and the target is not flying an erratic path, I would disregard tracer ammunition and rely wholly upon the sight.

D. Relative to the 3° gun depression I have not had the good fortune to track a Mig aircraft with this installation. However, I question the desirability of the 3° gun depression due to the inherent pendulum effect during tracking causing the pilot to always make a double correction when any correction is made. This, I believe, should be fully investigated by the Air Proving Ground Command and Nellis Air Force Base to find a desirable gun depression angle if one is needed.

E. Based upon hits observed last year on a Mig-15 that I was firing on and comparing that with film that I have seen with the Gun Val test, I would say that there is no question as to the increased effectiveness of the 20 mm installation as compared with the caliber .50 hits. I would also like to point out the effectiveness of the enemy's explosive rounds on our own aircraft, wherein two Gun Val aircraft have been completely put out of commission for several months requiring major repairs. This was due to three rounds. We definitely need an explosive round in our armament installation.

F. In my opinion, the present installation of four guns is adequate; however, I would like to caution that fewer guns with possibly more ammunition would not get the job done. The important thing is to have a density of fire at the point you desire to hit the target and not have less rounds for a longer time. The time on target is so short that it is imperative to get the maximum amount of rounds out there for a given time. I do not desire a selector switch in the four gun installation. I would also like to add that it is desirable to have the minimum of four guns due to the fact that future requirements may cause us to have to shoot down something besides a fighter type aircraft, and I believe a bomber will require you to have more guns in the installation.

G. With my short experience flying the Gun Val aircraft, I do believe that it is necessary to alter tactics slightly because of the armament installation. In fact, I believe that firing at longer ranges can be depended on in the future if we use this gun, thereby making the tactics a little bit easier. However, alteration in tactics as far as expended brass is necessary.

H. I do not like the range limiter on the sight and have not been using it due to the fact that I would take advantage of an aircraft at a longer range than is possible with the range limiter installation. I find that the caging button takes care of all abnormal actions of the sight and is all that is necessary. Adequate training would make the range limiter unnecessary. I do, however, find the in-range indicator portion of the range limiter a desirable feature and would like to see it on all future installations.

I. The sight reticle camera installation with the Zoomar lens erector heads seems to be a very satisfactory installation, and I would strongly suggest production for all fighter aircraft. I do not find that it obscures any visibility during combat; in fact, I have never noticed it at that time.

J. Until such time as the radar can be ground adjusted to a value which will hold for all altitudes and atmospheric conditions, I strongly suggest that the lock-on sensitivity control be installed in all aircraft with the G-30 radar set.

K. In addition to the above, I would strongly suggest that the Air Force embark on a program to determine the exact causes and reasons for compressor stall during gun fire on this installation. This is important for all future installations.

L. In summary, I would recommend that future fighter installations go to 20 mm type of armament to more effectively accomplish the job cut out for the fighter aircraft. This recommendation includes work against possible bombers, other fighters and air-to-ground work. I believe in going to the 20 mm installations we can justify large expenditure to build aircraft to do a job that they were originally designed for, that is, shoot down other aircraft.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 29 April 1953

B. Lt. Col. Clayton L. Peterson

C. Date of Pilot Rating: 16 August 1941

D. Total Flying Time: 2660 hours

E. Total Fighter Time: 2200 hours of which 1050 are jet hours.

F. Combat hours World War II: 514 hours. This included air-to-ground work, counter air work and escort.

G. Combat hours Korea: Approximately 60 hours

1. Fighter Bomber: None

2. Counter Air: Approximately 60 hours

H. Claims:

1. World War II: 2 damaged

2. Korean Theater: 1 damaged

I. None

PART II - Gun Val Combat Experience

A. Number of missions: 40

B. Number of engagements: 25

C. Number of firing passes on Enemy aircraft: 5

D. Claims: 1 damaged MIG

PART III - Pilot's Comments

A. I feel there is no great appreciable difference in climb, speed, maneuverability of Gun Val aircraft in comparison to F-86F aircraft equipped with .50 caliber guns up to approximately 42,000 feet. Above that altitude, I do feel

that the Gun Val aircraft are slightly inferior when compared to the regular .50 caliber equipped F-86F aircraft. There appears to be a decrease in the absolute ceiling of the Gun Val aircraft, a slight decrease in maximum speed and a greater deceleration in speed when attempting G turns at these altitudes. There appears to be a greater deceleration in the aircraft during the period of firing the T-160 guns, especially when firing over a long period of time. Very short bursts did not decrease the speed of the aircraft as far as I knew, any more than a short burst when firing the .50 caliber equipped aircraft; however, the greater difference is noted when firing long bursts.

B. I feel that the present 4½ seconds of fire of the Gun Val aircraft is inadequate and would like to see at least 6 to 8 seconds length of fire for future installations.

C. Because of certain errors in the sights that we have in operation at the present time, I feel that tracers are desirable. Tracers would be very desirable in case of a failure of the sight, or at times when accurate tracking is impossible.

D. The basic ideas of the 3° nose down gun depression type of harmonization appears to be sound. I have done a little air-to-air tracking with this type of harmonization and it appears to me as good, and in some cases, better than the present type harmonization used in this Group. In the air-to-ground work that I have done with Gun Val aircraft and this type harmonization, I feel that it is superior over the present type of harmonization used in the Group. It appeared that I was able to keep the sight on the target for a longer period of time, consequently allowing me to put a longer burst into the target. It also appeared that I was able to approach the target at a better angle. I definitely feel that this type harmonization warrants future study, particularly for air-to-ground work.

E. Although I have only damaged one aircraft, I have observed hits made by the 20 mm on other aircraft and have observed hits made on ground targets. From the results I have seen, I feel that the terminal effectiveness of the 20 mm as compared with the .50 caliber is much greater. In addition, the fact that HE ammunition can be used in the 20 mm gun makes this installation much more desirable than the .50 caliber gun.

F. I feel that the present installation of four guns is adequate and would not like to see fewer than this number because it would reduce the hit probability in firing at targets. However, I feel that the idea of the selector switch is desirable. On occasions there could be targets which would require a fewer number of guns or on extreme long range firing where the probability of hits would be small. I do not think that we would sacrifice anything in the aircraft or guns by putting in a two-way selector switch.

G. I do not think the shorter time of flight, the HE ammunition, higher cyclic rate or discharging spent cases, aircraft deceleration at time of fire, or the 3° depression of the guns will alter the tactics now used by F-86F's to any great degree, however, I might say the present length of fire, and perhaps the future six or eight seconds would alter the tactics slightly, only in the fact that the pilot would have to use greater discretion in choosing his time of fire. For instance, the pilot would have to be a little more careful in spraying the area and shooting at extreme long ranges or at impossible angles. In the present installation of .50 caliber with the length of fire being 15 seconds he can afford to waste a little more ammunition. However, in the present installation and perhaps in the future of the 20 mm, the pilot will have to use a little more discretion in expending his ammunition.

H. I feel that the range limiter is a desirable feature on these aircraft and particularly feel that the in-range indicator portion of the range limiter is desirable, not only for experienced pilots, but especially for new pilots.

I. I have not experienced too much difficulty in tracking with the Gun Val camera installation on the sight, especially since the more recent Zoomar type installation has been installed. However, I would like to add this point: Anything that restricts the view of a pilot in any way is undesirable, and I think continued research should be made to develop a smaller sight camera head for this installation. I think the sight reticle camera installation is highly desirable in training new pilots, and also in use in a combat area in order to point out mistakes of the pilot in tracking and in checking the harmonization of the individual aircraft.

J. I have used the lock-on sensitivity control at least three

times during the period of flying Gun Val aircraft and feel that until the sighting system is fool proof, this should be installed on future aircraft, because it is the only method the pilot has in attempting to correct a system malfunctioning in the air. In present types of installations, this lock-on sensitivity control can be done only on the ground.

K. I would like to make some additional remarks about the air-to-ground possibility of this installation. In the 3 missions that I have flown in air-to-ground work, the 3° nose down depression harmonization method, I felt, was very desirable. The results of the striking power of this weapon surprised me, especially the HE round which, when fired on a truck, were extremely effective. In my mind, there is no comparison between the API or HE round of the 20 mm as to the regular .50 caliber installation in terminal effectiveness for air-ground work. The damage done by the 20 mm installation is far superior. It is my opinion that the 20 mm guns now installed in the Gun Val aircraft are very desirable in future fighter aircraft. The shorter time of flight, the HE round, and the higher cyclic rate are a great improvement over the .50 caliber installation. The greater hitting power obtained from the 20 mm guns should improve the kill ratio now obtained by the .50 caliber installation. However, as mentioned before, we should have a longer rate of fire, at least 6 to 8 seconds, and we must eliminate the cause of the compressor stall which we now experience in our presently equipped 20 mm aircraft.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 22 April 1953.

B. Major Jack E. Mass.

C. Date of Pilot Rating: March 1944.

D. Total Flying Time: 1900 hours.

E. Total Fighter Time: 1500 hours.

F. Combat hours during World War II: 140 hours.

1. Type Missions: Fighter-Bomber Interdiction, escort with some air-to-air combat.

G. Combat hours Korea:

1. No fighter-bomber missions.

2. 115 Fighter-Interceptor missions for a total of 190 combat hours.

H. Claims:

1. World War II: One 109 destroyed. One FW-190 probably destroyed.

2. Korean Theater: Two Mig-15's destroyed; 7 Mig-15's damaged.

I. Experience as an armament officer 368 Fighter Group during World War II: 5 months.

PART II - Gun Val Combat Experience

A. Total Missions: 12

B. Number of Engagements: 3

C. Number of Firing Passes on Enemy Aircraft: 1

D. Claims: 0

PART III - Pilot's Comments

A. I do not believe that there is much of a penalty paid in

performance in Gun Val aircraft as compared with the normal F-86 with the .50 caliber installation; however, there is one slight penalty paid and that is the deceleration during gun firing. It slows the aircraft down considerably compared with the .50 caliber gun firing. It is not too great a penalty in my estimation. The only other penalty would be the possibility of a compressor stall at altitude firing all four guns; however, if every pilot had adequate knowledge of this condition, I think it could easily be remedied to a certain extent in recovering from the stall by knowing the things to do prior to firing all four guns.

B. I do not feel that 4½ seconds is adequate for firing from any jet type aircraft at the altitudes we are presently flying. I would like to see the length of fire increased to approximately 8 seconds. This would give a little longer duration and possibly make a few more definite kills; however, if the enemy aircraft was hit by 6 or 7 rounds of this type of ammunition, I am sure the aircraft would not reach its home base.

C. I do not feel tracers are <u>absolutely</u> necessary, but until such time as they can develop a fool proof sight that you can always depend on to function properly, I do believe that tracers are a necessity.

D. The 3^0 depression of guns is desirable as far as I am concerned due to the fact it will get you above the jet wash of the aircraft you are pursuing in order to get your sight on the aircraft, to keep the aircraft more stable, and to make your gun firing more accurate. I only fired on one Mig with the Gun Val aircraft, but I have observed other people's hits on film, and there is no doubt in my mind that the 20 mm installation is more desirable than the .50 caliber installation, but until such time that they can increase the length of fire to a few seconds more the .50 caliber gives you a chance to fire more bursts and stay in there just a little longer. The .50 caliber is more desirable at high altitudes, 45,000 up to 50,000 feet where a lot of our encounters are taking place at the present time.

E. No comment.

F. In my opinion the present installation of four guns is adequate, and no attempt should be made to decrease this number. If an aircraft could be built that could accelerate in comparison to the type airplane we are flying against now, and of course increase the length of fire, this installation would be the answer.

I do not believe there is a need for a selector switch in the aircraft to fire either 2 guns or 4 guns. When you are in firing range of an enemy aircraft, and you know the conditions that exist when firing all guns at high altitudes, and you know that the possibilities of compressor stall are right there, I believe anybody who finds himself in that position will not hesitate to try to get in range, throttle back and take a burst of all four guns, hoping to eliminate the compressor stall. If in the event he does not eliminate the compressor stall, he can immediately break off and head down and try to get rid of the stall.

G. I do not believe that this installation alters the tactics from the normal F-86 tactics. You will do the same maneuvers with this installation installed without any variation at all.

H. The range limiter stabilizes the sight at long range, and I find it very desirable in this aircraft. Also, the in-range indicator portion of the range limiter is indeed a desirable feature.

I. I particularly like the reticle camera installation especially since the adapter head has been modified. It does not restrict my vision, and I would like to see it installed in all aircraft primarily for better evaluation of combat film.

J. On a few occasions the lock-on sensitivity control had to be adjusted for altitude changes and atmospheric conditions.

K. My comments on the desirability of the 20 mm in future fighter installations is very much the same as those of the other pilots because of the type aircraft against which we are now flying in combat. There is no doubt in my mind that one 20 mm hit is equal to about 5 or 6 hits of .50 caliber. I have seen some of our aircraft come back that had been hit by the Mig-15's 37 mm and 23 mm, and considerable damage was done to the aircraft. I also think it was a good thing when they decided to make the change for this test so that in the future if you are to encounter the large type bomber aircraft, the fifties would not do the damage that the twenties will. The 20's would definitely give you a kill potential where the .50 would only knock out an engine or damage the aircraft slightly. I would definitely like to see the 20 mm improved and put into future type fighter aircraft.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 28 April 1953

B. Captain David T. Davidson

C. Date of Pilot Rating: 23 May 1944

D. Total Flying Time: 3010 hours

E. Total Fighter Time: 2030 hours

F. Combat hours World War II: 200 hours of fighter time. I flew 44 missions, mostly escort missions, in F-51 type aircraft.

G. Combat hours in Korea: 120 hours, all counter air.

H. Claims:

1. World War II: None

2. Korean Theater: 1 Mig-15 destroyed and one Mig-15 damaged.

I. I have been an engineering officer and fighter gunnery instr at Nellis Air Force Base, Nevada.

PART II - Gun Val Combat Experience

A. Number of Missions: 4

B. Number of Engagements: 2

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. I feel that the added weight of this particular installation in the F-86 has some effect on the maneuverability and the rate of climb of the airplane. I flew it with a flight of

normal F-86's, and it seemed as though there was a slight difference in the performance of the airplane. I do think it affects the aircraft in that manner. The only other thing I have against the installation is the compressor stall characteristic that is induced at high altitudes.

B. In my opinion, the present 4½ seconds of fire is not adequate. I personally think 7 to 10 seconds of fire would be more adequate and would do a better job.

C. I think tracers or some method of giving the pilot some indication of where he is shooting is highly desirable for combat airplanes. If the sight goes out or is not computing properly, you have no way of knowing where you are shooting and with the limited amount of fire it would be desirable to have some method of either the tracers or the beeswax on the ammunition to give you an indication of where you are shooting. I do not know the feasibility of putting tracers in, but I do advocate some method of giving the pilot some indication of where his bullets are going.

D. As far as the 3° depression of the guns is concerned, I think it is very desirable. I do not know if 3° is the correct amount or not; maybe 2° would be better. I do feel that you have a greater accuracy with the guns depressed. The more nearly the guns approach the flight path of the airplane the less gunnery error you have, and therefore you have greater accuracy with the guns depressed although you can't compensate for all changes of altitude and air speed. I think having the guns depressed is a better installation than having them mounted parallel to the longitudinal axis of the aircraft.

E. I do not think there is any question about the effectiveness of the 20 mm or the damage that it does. It certainly has greater destructive power than the .50 caliber, and the greater destructive power you have the more chances you have of getting a kill.

F. In my opinion, the present 4 gun set up is adequate, and it is the proper number. I think the gun selector switch is highly desirable. As far as fighter versus fighter combat is concerned, I think 2 guns would be adequate, however, against bomber, four guns would certainly be desirable. I think you can also use your selector switch to increase your time of fire by shooting two guns at a time when you are shooting against a fighter.

G. I do not think this installation appreciably affects the tactics used in standard F-86's, and the only tactics that it could change would be at high altitude firing and compressor stalls that we encounter.

H. The range limiter idea is fine, and it is a desirable feature in all fighter type airplanes and can be used to great advantage. However, I have not fired enough with the A-4 sight to become accustomed to the in-range indicator of that sight. I think the one on the A-1 with the reticle disappearing is a better feature than the blinking on the A-4.

I. As far as the sight reticle camera installation is concerned, I find it difficult as far as tracking and looking around the sight, but I suppose you get accustomed to it. I prefer not to have the sight reticle camera installation the way it is in these aircraft.

J. The lock-on sensitivity control is very good as far as I am concerned, and I think it should be on all the sights. I used it on almost every mission I flew.

K. I feel that the 20 mm installation is an approach in the right direction, and I think it is what we have been awaiting for a long time as far as fighters are concerned. The gun definitely has an advantage over the .50 caliber installation, and I think with the proper installation and remedying the compressor stalls in the F-86 at high altitudes, it is a very desirable gun. I do feel that the time of fire should be increased, and there should be some method of giving the pilot an indication of where he is shooting either with tracers or beeswax. As far as the T-160 gun itself is concerned, I feel that it is far superior to the .50 caliber.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 23 April 1953

B. Major Foster L. Smith

C. Date of Pilot Rating: 6 June 1944

D. Total Flying Time: 2500 hours.

E. Total Fighter Time: 485 hours.

F. Combat hours World War II: None.

G. Combat hours in Korea: 100 hours. All of it in F-86's in counter air and escort missions.

H. Claims:

Korean Theater: 1 Mig-15 destroyed.

PART II - Gun Val Combat Experience

A. Total Missions 5

B. Number of Engagements: 1

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. The performance of the Gun Val aircraft is okay, except that the center of gravity seems to have shifted slightly forward with the installation of the 20 mm weapons. There is a slight instability at certain speeds around .85 to .92 Mach, varying from aircraft to aircraft which is probably an individual characteristic, but it seems to be found in all the aircraft with this gun installation. The climb on the aircraft is satisfactory in that it is done at a higher than usual Mach. I have no criticism on the aircraft speed, at 42,000 feet and above, except that it is slightly lower than the .50 caliber installation. The maneuverability was affected

somewhat because of the nose heaviness. The deceleration during gun fire is greater per unit time, although I doubt if the deceleration is any greater per quantity of projectiles thrown, considering the cyclic rate of fire.

B. The length of fire, in my opinion, is too short. For present combat conditions it seems satisfactory, but I believe the optimum would give us 2 to 3 seconds more fire without unsatisfactory sacrifices in weight. I would think around 6½ to 7 seconds of fire ought to be satisfactory. For strictly air-to-air combat this seven seconds would be okay, but if we are to get into the business of shooting at bombardment aircraft, I believe that a longer period of fire is indicated even for this type of gun.

C. Personally, I would very much like to have tracers, especially as long as we have the critical problems of sights that sometimes malfunction. I especially like the tracers in the .50 caliber, and it would also be more desirable to have tracers with the 20 mm.

D. The 3^{0} depression of the guns is very desirable, in my opinion, because when shooting air-to-air with fighter aircraft you find that you ride above the Mig's jet wash.

E. I will have to base my judgment of the terminal effectiveness on photographs that I have seen and upon evaluation and assessment of film which has been made on missions wherein Gun Val aircraft have hit the Mig. In my opinion, the effect of the hits from the 20 mm installation are much more effective than hits from the .50 caliber.

F. As far as the number of guns is concerned, I believe that four is satisfactory for fighter-to-fighter work. In high speed bombardment intercepts, I think we are going to require a greater volume of fire power, and probably six guns or perhaps eight (depending on weight and speed limitations) would be desirable. I think six would be what is needed for tackling something like the B-47 or even the B-36. You have got to have more rounds than this will provide for such a target, since the superiority of bombardment gun armament will make itself felt with the advancement of sighting systems and electrical gunnery controls. The 4 gun installation is adequate for fighter-to-fighter work. I do not believe that fewer guns with more ammunition would be desirable. A selector switch in a four gun installation is desirable to a degree, if no increase in weight is made.

G. The installation of 20 mm guns in the F-86, in my opinion, does not materially alter the tactics required to shoot down a Mig. You still have the problem of closure - the problem of getting into position to fire. The only place that you have advantage is that it takes less duration of fire, with a higher cyclic rate and a higher shock effect of each individual round to disable or destroy a Mig. The equivalent damage can be effected in a much shorter time. Therefore, from a standpoint of time it is more advantageous to have this installation. In tactics it could mean that you could snap a shot and get out quickly and still get the same shock effect and destructive effect with the 20 mm installation.

H. As far as the range limiter is concerned, I think this is one of the most desirable features of the sight in that it presents to you a reference range. I believe it is a desirable feature on these aircraft as well as on any other aircraft.

I. As far as the sight reticle camera installation goes there has always seemed to be some difficulty in attaining a sufficient lateral visibility. In other words, as long as you have this reticle camera in here it is going to be hard to move your head from side to side as far as perhaps you would like in high-angle-off shots or in closing on a target out of a dive. In my opinion, the Gun Val camera installation on the sight is very good, however, in that it has the small periscope installation which takes up much less space. I like this development and the use of a wide angle lens with the periscope attachment on it. It takes up less space in the pilot's very limited area of vision.

J. The lock-on sensitivity control was never used by this pilot. Only when I get too sensitive lock-ons in clear air would I ever reduce the sensitivity of it. I believe it is most desirable to have this adjusted on the ground.

K. I believe that the 20 mm installation in future fighter installations is a step in the right direction. I do not believe it is the answer because we have got to take a long step ahead to meet first the problem of future fighters which we will encounter, and second, future bombardment and ator bomb carrying aircraft which we will encounter in the next 10 to 15 years. It is going to take at least 2 or 3 years to get this gun in a

production aircraft, and it will take a few years to prove itself. Meanwhile, we cannot rest with this particular 20 mm and come out on top, in my opinion. It is a tremendous improvement and will probably be adequate up until 1958 against possible enemy fighters, since, in my opinion, we do not need guided missiles in fighter-to-fighter work. I think we are going to need something heavier in its striking power per unit time against bombardment aircraft that may take us into the field of rocketry. It is certainly a step in the right direction, and the cyclic rate of fire must be held up no matter what variation you have in the size or caliber of the projectile being fired. I am all for Gun Val; I think it has been a tremendous success and only the problem of installation in the F-86F has kept it from being a complete success here. It is to be expected that a test aircraft is not going to deliver the same performance as a production aircraft, and when this gun gas problem is solved in the next installation of production aircraft we are going to have a real top notch air superiority fighter weapon.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 22 April 1953

B. Lt. Colonel Frank J. Keller. (Assigned to 81st Fighter-Interceptor Group in England. TDY to 4th Fighter-Interceptor Group.)

C. Date of Pilot Rating: 11 July 1941

D. Total Flying Time: 3870 hours

E. Total Fighter Time: 1850 hours. 1060 hours jet time with approximately 500 hours in the F-86.

F. Combat hours during World War II: 150 hours P-38 flying bomber escort and interdiction missions.

G. Korean Theater:

1. No fighter-bomber.

2. 40 hours combat time, counter air.

H. World War II Claims:

1. 2½ aircraft destroyed.

2. 2 damaged.

I. None.

PART II - Gun Val Combat Experience

A. Total Missions: 9

B. Number of Engagements: 2

C. Number of Firing Passes on Enemy Aircraft: 2

D. Claims: 2 damaged.

PART III - Pilot's Comments

A. There is apparently a slight penalty in performance of Gun

Val aircraft as compared to other F-86's with .50 caliber. The climb and ceiling are slightly lower and the deceleration during gun fire is more noticeable.

B. I believe that 4½ seconds is not adequate for the type of combat being experienced here. I believe that we should get at least 8 or 9 seconds of fire as a minimum.

C. I believe, because of the complications of sighting, that tracers are highly desirable.

D. Although I have only fired Gun Val aircraft at two MIGs in combat, I feel that the 3° depression of the guns might be undesirable. I feel that the most effective gunnery can be accomplished when the guns are boresighted as closely to the longitudinal axis of the aircraft as possible.

E. Judging from combat camera film and pilots' remarks, it is apparent to me that the 20 mm installation as compared with the .50 caliber is more effective.

F. I feel that the present installation of four guns would be adequate, and I do feel that the selector switch in the four gun installation to allow the pilot to fire two or four guns is desirable. This is because of the variable combat conditions which fighter pilots find themselves, that is, range, altitude, maneuverability of the target, etc.

G. I do not believe this installation affects the tactics now being used by the standard F-86.

H. I feel that the range limiter which stabilizes the sight at long ranges is a desirable feature. The in-range portion of the range limiter is also a desirable feature.

I. I have not noticed any difficulty in visibility of tracking with the Gun Val reticle camera installation. I feel that this reticle camera is highly desirable.

J. The lock-on sensitivity control was used on test missions; however, it was not used in actual combat.

K. I feel that in future fighter installations, we should have a weapon as effective as the 20 mm, at least. If at all possible we should have more effective weapons; this is due to the fact that the future high Mach aircraft will be built

much stronger and therefore will be much harder to damage and destroy. The comparative ineffectiveness of the .50 caliber has been shown repeatedly here in the Korean theater. Many hits on the Mig aircraft have been observed, but the Mig in many cases could still outclimb the F-86 and evade destruction.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 29 April 1953

B. Lt. Colonel J. R. Best.

C. Date of Pilot Rating: 29 May 1941

D. Total Flying Time: 2300 hours

E. Total Fighter Time: Approximately 800 hours.

F. Combat hours in World War II: Approximately 100 hours broken down as follows:

1. 50 hours counter air.

2. 30 hours interdiction.

3. 20 hours escort.

G. Korean Combat Hours: Approximately 40 hours all counter air.

H. Claims:

1. World War II: One Zero destroyed, one probably destroyed.

2. Korean Theater: None.

I. None.

PART II - Gun Val Combat Experience

A. Total Missions: 1

B. Number of Engagements: 0

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. Regarding aircraft performance I have very little information

on which to base a comparison between the Gun Val aircraft and other F-86's as I have only flown the F-86E model with slats. The Gun Val aircraft being an F-86F with a straight edged wing is greatly superior in performance at high altitudes.

B. Regarding the length of fire, I do not have enough experience to form a definite opinion; however, I believe that 4½ seconds is less than I would desire. However, the present 15 seconds on the .50 calibers is excessive. I would say approximately 8 seconds would be a good compromise for future installations.

C. I would like to see tracers, particularly for test firing. They are very helpful when firing at a Mig.

D. I have had no personal experience with the 3° depression of the guns; however, from the film I have seen I would say that there is one undesirable characteristic in that when tracking in from 6:00 o'clock there is a tendency to track in a curve which brings you up through the jet wash of the enemy aircraft. At high altitudes the resulting unstable condition makes the probability of a kill very much less.

E. I have no experience which would be of value in determining the effectiveness of 20 mm hits compared to the .50 caliber.

F. I do believe the four guns are adequate. I would not like to see any less than four. A slightly longer period of fire would be desirable. I do not think a selector switch to select two or four guns is necessary except as in the present installation where it is an aircraft factor rather than a gun factor.

G. In my limited experience with this installation, I do not feel qualified to make any comments regarding tactics; however, from observations formed on the experience of others, I do not believe the tactics are altered to any great degree by virtue of the installation of the 20 mm gun.

H. I find the range limiter to be of great value in tracking and firing in both the A-1CM and the A-4 sight. I find the in-range indicator a very desirable feature.

I. The sight reticle camera installation on the Gun Val aircraft, I believe, is excellent. The camera head in the windshield is hardly noticeable at all when working with the sight.

J. I did not use the lock-on sensitivity control for the sight.

K. As an overall comment on the Gun Val Project, I feel strongly that there is a great future for the 20 mm gun in fighter installations. There are many disadvantages at the present time; however, I think research presently underway will overcome those in the future.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 23 April 1953

B. Captain Vincent E. Stacy

C. Date of Pilot Rating: June 1944.

D. Total Flying Time: 1900 hours.

E. Total Fighter Time: 900 hours.

F. World War II Time: None.

G. Combat Hours Korea:

1. No fighter bomber missions.

2. 160 combat hours.

H. Claims for World War II: None.

Korean Claims:

1. 1½ destroyed.

2. 1 probable

3. 5 damaged

I. None.

PART II - Gun Val Combat Experience

A. Total Missions: 3

B. Number of Engagements: 1

C. Number of Firing Passes on Enemy Aircraft: 1

D. Claims: 0

PART III - Pilot's Comments

A. I noticed very little difference in aircraft performance on

the Gun Val aircraft compared with the leading edge F-86F as far as climb, speed, ceiling and maneuverability is concerned. The normal F-86F has a very slight edge on it. The deceleration while firing the guns was noticeable.

B. The length of fire was adequate in most cases, but it would be more desirable if there were 8 to 10 seconds of fire.

C. Tracers would be very desirable especially at close ranges and high Mach.

D. I like the 3^{0} depression of the guns. It keeps you out of the jet wash at certain ranges where you could get a smoother gun platform from which to fire.

E. From what I have seen of the hits from the Gun Val aircraft of the 20 mm ammunition, I believe it is very lethal, especially at close ranges. As compared to the .50 caliber, the only objection I have is that there are no tracers and the firing time is short.

F. The amount of fire power in this installation is very adequate, and if the guns could be boresighted to bring the pattern in a few mils to have a more concentrated fire power, I think we would have a very lethal installation. The gun selector switch in the four gun installation is desirable, but if I had 10 seconds of fire in these guns I would not want a selector switch.

G. I do not believe any of the shortcomings of the Gun Val aircraft hinder the tactics now being employed by standard F-86F aircraft. The tactics in all circumstances were about the same.

H. I found that some times in close ranges the sight would oscillate, and the range limiter would be a desirable feature if they could take some of the oscillation out of the sight. The in-range indicator on the range limiter is a very good feature.

I. The sight reticle camera installation did cause a little difficulty in tracking but the new erector head that is now installed eliminates this difficulty.

J. The lock-on sensitivity control is another desirable feature in the fire control system. It allowed me to stabilize the radar and control it and to know what its capabilities were, and whether or not it was in commission.

K. On the overall picture, I think that if they improve the mounts, the pattern of the 20 mm, the length of fire, and get rid of some of the weight if possible, the 20 mm will be the answer to future fighter installations.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 22 April 1953.

B. Captain Clyde A. Curtin.

C. Date of Pilot Rating: 12 December 1941.

D. Total Flying Time: 3300 hours.

E. Total Fighter Hours: 2200 hours.

F. Combat hours during World War II: 15 hours interdiction missions.

G. Combat hours in Korea:

1. Fighter -Bomber - None.

2. Counter Air - 130 hours in 85 missions.

H. Claims:

1. World War II:

a. 1 Ramp (ground).

b. 6 locomotives and trains.

2. Korean Theater:

a. 2 Migs destroyed.

b. 3 Migs damaged.

I. Two years experience as instructor at Air Force gunnery squadron.

PART II - Gun Val Combat Experiences

A. Total Missions: 5

B. Number of Engagements: 2

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. Gun Val aircraft seem to be heavier on take-off and climb characteristics with a corresponding loss of ceiling and maneuverability at altitudes. The deceleration during firing is noticeable but is more than off set by the striking force of the fired projectiles.

B. The length of fire combined with the lack of tracer ammunition and the evasive maneuvers of the enemy aircraft indicate that a longer duration of fire is desirable. With the large number of targets available in this theater, 8 to 10 seconds of fire would be my recommendation.

C. With the lack of reliability of the present sighting system on the F-86 and the short duration of fire with the 20's, it is mandatory that tracer ammunition be furnished with this gunnery installation. The wax coating on the ammunition is of slight help in ascertaining a desirable sight picture. This is determined from the sighter burst. The wax trails were not adequate as they burned out at about 800 feet.

D. The 3^{0} depression on the guns is both desirable and undesirable. It is desirable from the point of view that you are above the jet wash of the other aircraft, but it is undesirable from the point of view of maintaining proper sight picture due to over controlling. A pendulum type oscillation is encountered on attempting small corrections. In comparing this set up with that of an F-86 with .50 calibers, I believe that an overall conclusion would favor the Gun Val installation.

E. When the 20 mm hit with effective force, the results are very good, but I believe that several aircraft that were not destroyed could have been shot down had the aircraft been carrying a full load of .50's. This is, of course, based on the length of fire and the fact that there were no tracers on the 20's.

F. Four guns are more than adequate. The selector switch for 2 or 4 guns was used by the pilot on all missions and I feel that it would be desirable on future installations.

G. There were no changes of tactics caused by the Gun Val aircraft.

H. It is my belief a range limiter on the A-1 CM or the A-4 gun sight is of no value and should not be utilized on future fighter type aircraft. The A-4 sight will give proper computations at all ranges. When you utilize the range limiter on the A-4, you immediately put in a booger factor. If you fire a slight bit out of range, you have to estimate how high you have to aim above the Mig. This, of course, destroys the ranging and computing functions of the A-4 sight.

I. No comment.

J. No comment.

K. No comment.

L. I believe that future installation of the 20 mm weapon in fighter aircraft is desirable, not particularly against the Mig-15 or other type fighters, but would be mandatory if we were fighting against bombers. The .50 caliber, I believe, would be totally inadequate against bomber type aircraft; of course the fifties are more than adequate when firing fighter against fighter.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 28 April 1953.

B. Captain Houston N. Tuel.

C. Date of Pilot Rating: September 1944, Fighter Pilot since May 1950.

D. Total Flying Time: 3700 hours.

E. Total Fighter Time: 1150 hours with approximately 1100 hours in jets.

F. World War II Time: 50 hours as an artillery liaison pilot.

G. Korean Theater: 180 hours in F-86's all of which has been air-to-air work.

H. Claims:

1. World War II: None.

2. Korean Theater: 3 Mig-15 type aircraft destroyed and one damaged.

I. I have no other experience than just a plain fighter pilot.

PART II - Gun Val Combat Experience.

A. Total Missions: 3

B. Number of Engagements: 0

C. Number of firing passes made on enemy aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. From my experience I cannot say if there is a penalty in performance since the only F-86F with the straight edge that I have flown has been the Gun Val aircraft. However, the one thing that I did notice is that there is a very noticeable deceleration while the guns are firing, much more noticeable than the .50 calibers in the F-86E.

B. I believe the 4½ seconds length of fire is adequate.

C. I like the tracers for test firing, not necessarily though for other than test firing.

D. As for the 3° depression of the guns, I do not really know enough about that to have an opinion on it.

E. I have never seen a 20 mm hit on an enemy aircraft; I can only guess that it would be more effective than the .50 caliber. I recall at least one case where I observed several .50 caliber hits on the aft section of the MIG, and his performance did not seem to be affected at all. I believe in that particular instance the 20 mm would have stopped this particular MIG.

F. On the present Gun Val aircraft I believe the gun installation is adequate, both with respect to the number of guns, the ammunition and time of fire. I do not think we should have less than 4 guns. The selector switch, using 2 or 4 guns, is a desirable feature on the present installation, but it might not be on an aircraft where we did not have to worry about compressor stalls at high altitudes.

G. From my experience in Gun Val aircraft, I do not think the tactics have been altered.

H. The range limiter, in my experience, has not been necessary; in fact, it has caused me a little trouble at times when the target was beyond the maximum setting of the range limiter with no time to change it during the attack.

I. The sight reticle camera did not bother me at all. It seems to fit very well in the aircraft, and it did not affect me when I was flying the aircraft.

J. I had no occasion to use the lock-on sensitivity control. In practice, I checked it just to see if the light worked, but I do not know how necessary it is.

K. In summary, I think the four 20 mm guns in the F-86 would raise the kill-damage ratio favorably because of the greater striking power and possibly greater accuracy at long ranges. However, I think it would be necessary to have an installation that will permit unrestricted use of the guns at all altitudes.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 27 April 1953.

B. Captain R. T. Dewey.

C. Date of Pilot Rating: 7 January 1944.

D. Total Flying Time: 2000 hours.

E. Total Fighter Time: 1300 hours.

F. Combat Hours World War II: 288 hours. World War II experience included approximately 90 missions of close support, dive bombing and about 10 counter air missions, and the rest were escort missions of such type as heavy bombers and light bombers. A total of 148 missions were flown during World War II.

G. Combat Hours Korea: Approximately 100 hours. Counter air approximately all the time.

H. Claims:

1. World War II: One ME109 destroyed. One ME262 probably destroyed.

2. Korean Theater: One Mig-15 type aircraft destroyed; one Mig-15 probably destroyed.

I. This pilot has had no experience as an armament or a gunnery officer; however, he has been able to spend a good deal of time practicing dive bombing, strafing and other tactics as applied to fighter bomber work.

PART II - Gun Val Combat Experience

A. Total Missions: 2

B. Number of Engagements: 0

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. In my opinion, the Gun Val aircraft does outclass the F-86E and is almost equal to the leading edge .50 caliber F-86F aircraft. At altitudes this aircraft is slower to turn due to the extra weight, and it requires more attention from the pilot to allow him to maintain a high Mach without losing altitude. At low altitude I found the deceleration of the aircraft during gun fire to be greater than the .50 caliber installation but is still no detriment to the performance or tactics used in the aircraft.

B. As far as the length of fire in Gun Val aircraft, I believe it is adequate for the type missions that I flew.

C. The system used here with beeswax on the ammunition to provide marking of the projectile path is, in my opinion, better than tracer ammunition.

D. I am unable to make a comment on the 3° depression of the guns.

E. I am in favor of the hitting power and range of the 20 mm installation over the .50 caliber.

F. If the problem of compressor stall at altitude can be removed and the four guns can be fired at all altitudes, I feel that they would be adequate and should fire altogether. In other words, 4 guns fired all the time, no switch over change.

G. Tactics with the Gun Val aircraft are no different from those of the standard F-86 aircraft.

H. I did not use the range limiter, when installed, as I feel that having the electric caged position is all that is necessary. When you are not pressing the electric caged button, the sight computes the proper amount of lead for the target that it has locked on.

I. As the forward vision of the F-86F is limited by many bars and braces I, for one, do not like the sight reticle camera. It just provides another hazard that you have to look around. Although I do feel that the sight picture during firing is a desirable feature.

J. The lock-on sensitivity control is a good thing and should be incorporated in all radar sights that we have.

K. As a last word, let's have more 20 mm on more fighter type aircraft to replace the .50 caliber.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 1 May 1953.

B. Lt. Colonel Philip E. Joyal.

C. Date of Pilot Rating: 13 December 1941.

D. Total Flying Time: 3200 hours.

E. Total Fighter Time: 2300 hours.

F. World War II Combat Hours: None.

G. Korean Combat Hours:

1. No fighter bomber.

2. 130 hours counter air.

H. Claims:

1. World War II: None.

2. Three Mig-15 type aircraft damaged.

I. None.

PART II - Gun Val Combat Experience

A. Total Missions: One.

B. Number of Engagements: None.

C. Number of Firing Passes on Enemy Aircraft: None.

D. Claims: None.

PART III - Pilot's Comments

A. One flight would not make a good evaluation. Aircraft seemed to be faster and more effective than the F-86E's which I had been flying.

B. Although I have never fired Gun Val at an enemy aircraft, it is a natural reaction to want more time of fire. I believe that the time of fire of Gun Val should be at least half that of the normal F-86.

C. My opinion, based on experience with .50 caliber in combat, is that tracers will render the equipment much more effective. For one thing it will stop a pilot from wasting ammunition when he has aimed incorrectly.

D. I am not familiar enough to make a comment on the 3^{0} depression of the guns.

E. From observing Gun camera film, I would say that the Gun Val ammunition is at least 50% more effective.

F. I believe the four guns is adequate and should not be reduced. The system should be such that two or four guns could be selected.

G. I am not familiar enough with the equipment to render an opinion as far as tactics are concerned. I do not believe the tactics would be altered with the exception that initial long range bursts designed to slow the enemy aircraft down would have to be eliminated due to the short length of fire.

H. I feel that the range limiter is a desirable feature and also the in-range indicator.

I. I did not fire at a target so I cannot personally state whether there would be any difficulty in tracking with the sight reticle camera installation.

J. I did not use the lock-on sensitivity control on my mission.

K. I am in favor of installing 20 mm in future fighter aircraft with the following stipulation: Longer time of fire.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 20 April 1953.

B. Captain William H. Champion.

C. Date of Pilot Rating: December 1944.

D. Total Flying Time: 3050 hours.

E. Total Fighter Time: 1400 hours.

F. Combat Hours World War II: None.

G. Combat Hours Korea: 115 Hours, counter air.

H. Claims:

1. World War II: None.

2. Korea: None.

I. Combat crew instructor at Nellis Air Force Base for 2½ years.

PART II - Gun Val Combat Experience

A. Total Missions: 1.

B. Number of Engagements: 0.

C. Number of Firing Passes on Enemy Aircraft: 0.

D. Claims: 0.

PART III - Pilot's Comments

A. The flying characteristics and maneuverability of the Gun Val aircraft were found to be excellent.

B. The 4½ seconds of length of fire that we now have available is believed adequate for this theater.

C. I believe that tracers are an advantage in any airborne combat weapon.

D. The 3° depression of the guns is believed to be very sound and further research should be conducted, especially for fighter versus bomber and air-to-ground firing.

E. The effectiveness of this weapon is far superior to our present .50 caliber and believed to be as accurate.

F. I believe the present installation of four guns is adequate, and I would not desire fewer guns with more ammunition. I also believe that the four gun installation with the selector switch to allow you to fire 2 guns or 4 guns is highly desirable.

G. No comment.

H. No comment.

I. No comment.

J. No comment.

K. No comment.

L. No comment.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 30 April 1953.

B. Captain Peter J. Fredricks.

C. Date of Pilot Rating: 23 May 1944.

D. Total Flying Time: 1350 hours.

E. Total Fighter Time: 1015 hours.

F. Combat hours World War II: 227 hours - 87 fighter-bomber missions.

G. Combat hours Korea:

1. No fighter-bomber missions, all fighter-interceptor work.

H. Claims:

1. World War II: None.

2. Korean Theater: 2 destroyed.

PART II - Gun Val Combat Experience

A. Total Missions: 1

B. Number of Engagements: 0

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. As for aircraft performance with the straight leading edge, there appeared to be an increased amount of maneuverability particularly noticed at altitudes. There was no noticeable change in climb, speed and ceiling although there was a noticeable deceleration when firing all four guns when returning from the mission.

B. Though there are only 4½ seconds of firing time available to the pilot, it appeared that this was a sufficient amount, in fact more than I expected. By firing short bursts I had to squeeze the trigger approximately 6 or 7 times, and it seemed to be a sufficient amount of firing time available to destroy an enemy aircraft.

C. As for tracer ammunition, it would probably help to turn an enemy aircraft in hot pursuit; it is actually not necessary because the wax type tracer can be easily seen under most conditions.

D. I do not feel thoroughly qualified to answer as far as the 3° depression of the guns due to the fact that I have been unable to fire on enemy aircraft.

E. I also do not feel qualified to make any comments with reference to the terminal effectiveness of this weapon. I have not observed any hits with the 20 mm installation.

F. I am entirely satisfied with the present installation of four 20 mm cannons. I would like to see the selector switch enabling the pilot to switch from 4 to 2 guns, and thereby fire and damage with the possibility of slowing up an enemy aircraft without too much deceleration. This would give the pilot the choice of selecting the four guns after closing in for a kill.

G. I am not fully qualified to recommend any changes in tactics used with this type installation. It is felt that any alterations in the tactics now being used by standard F-86's would be very minor and easy to overcome.

H. Although I did not have an opportunity to use the range limiter I found the in-range indicator to be helpful.

I. The sight reticle camera installation was a little annoying at first but was easily overcome. I prefer this type installation over the nose type installation.

J. I did not use the lock-on sensitivity control on this mission, and I do not consider myself fully qualified to comment on its usefulness.

K. As far as the 20 mm installation in future fighter aircraft is concerned, I would like to see them adopted, although there is less firing time. There is a greater destructive power firing a shorter time on target and a more positive chance of a destruction.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 28 April 1953.

B. Captain Robert A. Windoffer.

C. Date of Pilot Rating: 5 December 1943.

D. Total Flying Time: 2500 hours.

E. Total Fighter Time: 1800 hours.

F. Combat hours during World War II: 12 hours, mostly interdiction work.

G. Combat hours in Korean Theater: 185 hours all of which are counter air.

H. Claims:

1. World War II: None.

2. Korean Theater: One Mig-15 destroyed and one damaged.

I. I have been a gunnery officer for three years in ADC and also three months here with the 336th Fighter-Interceptor Squadron prior to becoming Operations Officer.

PART II - Gun Val Combat Experience

A. Total Missions: 2

B. Number of Engagements: 0

C. Number of Firing Passes on Enemy Aircraft: 0

D. Claims: 0

PART III - Pilot's Comments

A. First, there is a small sacrifice made in the Gun Val aircraft as compared to the normal F-86 in climbs above 40,000

feet. The Gun Val aircraft does not climb quite as well which may be due to the extra weight. This also makes the rolling a little bit lower than the normal F-86. As far as maneuverability is concerned, I think the Gun Val aircraft is capable except in extremely tight turns where it stalls [illegible] a little sooner; the speeds are the same on both models. During gun fire the Gun Val does have more deceleration than the .50 caliber F-86; however, I do not believe that this fact is too detrimental.

B. In my opinion, the length of fire is not long enough. If the length of fire were increased to 6 or 8 seconds with every tracer round during the whole load, it would improve the Mig kill ratio considerably.

C. No comment.

D. The 3° depression of the guns is good, I believe, because it improves killing range.

E. The 20 mm will knock down a Mig with less hits which is a very favorable point.

F. The four gun installation is fine, and I do not think the number of guns should be cut down to increase the amount of ammunition. The ammunition should be increased in other ways, if possible. The selector switch to allow the pilot to fire 2 or 4 guns, I think is a fine idea.

G. I do not believe the tactics are affected at all.

H. The range limiter stabilizing the sight at long range is very desirable, and I do not believe the in-range indicator is needed for an experienced sight man.

I. The sight reticle camera is a little objectionable but can be gotten accustomed to in a short time.

J. The lock-on sensitivity control was used during flights, and I think it is a good feature.

K. For future fighter installations I believe that the 20 mm's are very desirable with a few minor changes.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 10 April 1953.

B. Captain Murray A. Winslow.

C. Unknown.

D. Unknown.

E. Unknown.

F. Unknown.

G. Unknown.

H. Claims:

1. World War II: Unknown.

2. Korea: 4 destroyed.

I. Unknown.

PART II - Gun Val Experience.

A. Total Missions: 3

B. Number of Engagements: 3

C. Number of Firing Passes on Enemy Aircraft: 2

D. None.

PART III - Pilot's Comments

A. Effectiveness from hits was not observed personally by me although I am of the opinion that the .20 mm ammunition as compared to the .50 caliber ammunition is much greater and effective in fighter type aircraft against the Mig type aircraft we are fighting in this area. I give this opinion due to the fact that I believe a strike by a 20 mm instead of a .50 caliber would have slowed down the enemy aircraft to the point where we could get into a good effective firing range and finish him off.

B. I believe the length of fire for this particular type aircraft is too short, considering the overall experience level of the type pilots that will fly our fighter type aircraft. I would consider 6 to 10 seconds to be more desirable.

C. As far as accuracy is concerned, I believe tracers would have helped considerably in one instance when I fired on a Mig with this weapon. I feel that there is a requirement for tracers.

D. The change of tactics of the aircraft with the 3^0 depression of the guns appeared to be very slight and did not appear to effectively change any tactics as far as this theater of operations is concerned.

E. Comparing this installation with the .50 caliber, I do think the 20 mm is a much better gun to have installed. The reticle vibration and the deceleration of the aircraft is noticeable, but I do not believe that it would change the advantages of having the T-160 guns.

F. No comment.

G. No comment.

H. The range limiter appeared to work fairly well. The blinking of the sight reticle was adequate, and I do not believe it was too intense. The range limiter did help me to track more accurately, but due to the fact that I could not close to a point where I had the range limiter set, it did not particularly help me. If I had had the time to reach up and change the range limiter to a greater range, I would have been more accurate with my firing. I do think the range limiter, if the pilot is properly trained in the use of the sight, can be very desirable in the type of combat flown here.

I. The reticle camera will not greatly hinder the pilot in his forward vision.

J. The radar lock-on sensitivity control, the sight, and the range limiter, I believe, are very helpful to new pilots. However, in order to properly use the forementioned items of the fire control system, each new pilot must be properly instructed as to their usage and operation.

K. Just as an overall summary of my particular experience with the Gun Val aircraft, I do feel that a caliber gun larger

than the .50 caliber. The 20 mm is very adequate although the length of fire is too short considering the overall experience level of pilots who fly the aircraft.

L. Although I am of the opinion that the 20 mm ammunition as compared to the .50 caliber ammunition is much greater and more effective in fighter type aircraft against the Mig type aircraft we are fighting in this area, effectiveness from hits has not been personally observed by me.

GUN VAL PILOT SUMMARY REPORT

PART I - General Pilot Background

A. 14 April 1953.

B. Colonel George L. Jones.

C. Date of Pilot Rating:

D. Total Flying Time: 2864 Hours.

E. Total Fighter Time: 2077 Hours.

F. Combat Hours World War II: 112 Hours.

1. Combat hours in World War II were flown in P-47 aircraft participating in long range fighter bomber strikes over Japan and China.

G. Combat Hours Korean Theater:

1. Counter Air: 280 combat hours flown in F-86A, E and F type aircraft against Mig-15's. These missions were flown over a period of time extending from June 1951 to April 1952 and January 1953 to April 1953.

H. Claims:

1. Korean Theater: 6-1/2 Mig-15 aircraft destroyed; 4 Mig-15 aircraft damaged.

I. Gunnery Experience: Instructed in fighter gunnery in F-47's, F-51's and F-86 aircraft as Flight Commander and Squadron Commander.

PART II - Gun Val Combat Experience

A. Total Missions: 40

B. Number of Engagements: 25. Engagements include only those occasions during which my flight maneuvered for position to fire on Mig-15's or the Mig-15's attempted an attack on us. Occasionally several engagements occurred during one mission.

C. Number of Firing Passes on Enemy Aircraft: 14. This total includes firing several bursts at the same Mig on those occasions during which a Mig was bounced and chased around

the sky for 5 or 10 minutes.

F. Claims: 2 Mig-15 aircraft destroyed. 1 Mig-15 aircraft damaged.

PART III - Pilot's Comments

A. Aircraft Performance:

1. A slight penalty in aircraft performance is paid for in the Gun Val installation. This small reduction in aircraft performance is evident in the climb and handling characteristics of the Gun Val aircraft at altitudes of 45,000' and higher.

2. The level flight and maximum dive speed of Gun Val aircraft is equal to that of the standard F-86 aircraft. However, in my opinion the standard F-86 has a slightly higher ceiling than the Gun Val aircraft. This assumption is based on several instances during which Gun Val aircraft and standard aircraft were flown in a lengthy stern chase against high flying Mig-15 aircraft. On these occasions the standard F-86 achieved a 1500' to 2000' altitude advantage over the Gun Val aircraft. (Note: However the Mig still climbed away from both F-86's.)

3. Maneuverability: Gun Val aircraft maneuverability in combat vs Mig-15's was not affected to any great degree by the T-160 installation. The slight difference between a Gun Val F-86 and .50 caliber F-86 is the greater nose heaviness of Gun Val aircraft which is noticeable above 45,000'. This can be handled by judicious use of stick trim and stick pressures.

4. Deceleration: The speed drop off during the firing of all four guns on a 1½ to 2 second burst is much more noticeable in the Gun Val installation. This becomes especially apparent when firing on enemy aircraft at high altitudes and slow air speeds.

B. Length of Fire: Four and one half seconds of fire is inadequate to effectively cope with the combat firing situations most usually encountered. To meet present and immediately foreseeable combat conditions, it appears that 9 to 10 seconds of fire should be provided. This is based on firing opportunities as they are influenced by the present fire control system, aircraft performance and installed armament.

C. Tracers: Combat experience in Korea indicates that the use of tracer ammunition is highly desirable in air-to-air combat. The fire control system now in use will not compute accurately under all combat firing conditions. The use of tracer ammunition as an aid to the fire control system when used in conjunction with the sight, has resulted in the frequent destruction of enemy aircraft which would have otherwise gone unscratched. Aside from the primary use of tracers as mentioned, tracers are helpful to a pilot when firing on aircraft which is out of harmonization or when using a sight which is malfunctioning. Both situations are common occurrences in the field.

D. 3° Nose Down Guns: In my opinion the 3° nose down installation in the F-86 makes it difficult to track a target from directly astern because it forces the pilot to fly in jet wash in order to hold the pipper on. The resulting yaw and pitch movement of the aircraft not only hinders accurate sighting but probably increases bullet dispersion considerably.

E. Terminal Effectiveness: The terminal effectiveness of this 20 mm installation is much greater than the .50 caliber installation. As an example: using standard ".50's" I fired at a Mig from dead astern range 000' and altitude 20,000'. The firing burst was a 2½ to 3 second burst, the pattern completely covered the Mig's fuselage and the Mig went down burning. Under almost identical circumstances I fired on a Mig using the T-160 installation. This time the altitude was 42,000' and I fired a 2 second burst. The Mig's fuselage was blanketed with hits. In less than a second this Mig went down burning so heavily that the last half of the burst was probably ineffective because the smoke was so dense I could not see what I was shooting at.

F. Number of Guns:

1. The present four gun installation fulfills combat requirements from the standpoint of terminal ballistics effectiveness, rate of fire, and dispersion pattern.

2. I do not believe that fewer guns with more ammunition would be a desirable compromise, because of the reduced hit probability of such an installation, unless they were mounted in an aircraft which possessed a definite performance advantage over the aircraft against which it was flown. The most effective way to raise the hit probability rate for any installation is to have a positive rate of closure and "get close" before firing.

3. A selector switch would be desirable to allow the pilot to fire two or four guns, depending upon the circumstances. However, this type of switch is not absolutely required.

G. Tactics:

1. The tactics used by pilots flying standard F-86 aircraft as compared to tactics used when flying T-160 modified F-86's are identical. They are primarily offensive tactics designed to place the attacking element into effective firing range and position.

2. The T-160 installation did not show a consistent increase in effective firing ranges over that of the .50 caliber installation. Primarily this can be attributed to the problem of fire control when firing at small fast-moving targets at long ranges. Major characteristics of the installation together with remarks as to effectiveness as compared to the .50 caliber installation and tactics are as follows:

a. Higher Cyclic Rate

Total rounds per minute almost the same as the .50 caliber installation thus affording almost equal hit probability with much greater destructive power. This factor increased effectiveness of tactics used.

b. Shorter Time of Flight of 20 MM

Made no apparent difference in fire control effectiveness under 2000' range and at ranges approaching 3000'. I doubt that the 20 mm projectile has a greater retained velocity than the .50 caliber due to the better sectional density of the .50 caliber projectile.

c. Four and One Half Seconds of Fire

Reduced the effectiveness of the tactics used when compared to the 15 seconds of .50 caliber fire available.

d. Discharging Spent Cases

No effect on tactics. Wing men had no trouble in avoiding discharged cases.

e. Aircraft Deceleration

At very high altitude firing at slow airspeeds, the

deceleration reduced effectiveness of the tactics used. Deceleration was not particularly noticeable when firing at high Mach speeds.

f. 3° Depression of Guns

In my opinion nose down depression of the guns reduced effectiveness of tactics used because it forced the pilot into flying in the jet wash when tracking a target flying straight away from him.

g. 1921 Rounds

Many times more effective than the .50 caliber round. This one factor alone greatly increased the effectiveness of the tactics used.

h. Defensive Tactics

The T-160 installation did not change defensive tactics used.

H. Range Limiter:

1. The range limiter is a definite assist to the present fire control system. The in-range indicator portion of the range limiter is very important since the pilot can be sure he is in range without taking his eyes off of his target.

I. Sight Reticle Camera Installation, which was first utilized by the Gun Val aircraft was too large and did effect the pilot's visibility when attempting to pick up or track a fast moving target. The new reticle which was finally installed in these aircraft was a greatly improved reticle installation and a definite asset to the armament system. I highly recommend a reticle of this type of installation in future fighter aircraft.

J. The Lock On Sensitivity Control was used on practically every mission. This feature increases the effectiveness of this fire control system.

K. Additional Comment: No amount of fire control equipment will ever pay for itself if it is mounted on a gun platform from which a pilot fires from an out of range position, either through lack of pilot ability and judgment or through sheer lack of aircraft performance.

L. Summary: In air combat today there is a definite requirement for a HEI round which penetrates and rips and tears large areas of aircraft structure. The requirement for this type of projectile will increase in the future as aircraft structural strength is increased to meet the stresses of higher speeds.

Combat experience in Korea has shown that an aircraft hit and damaged by cannon fire (Mig-15 fire) can seldom be returned to a combat in commission status, even though the pilot was able to fly it back and land at his home base.

The Gun Val T-160 Gun was tested under the following conditions in combat which seriously limited its combat effectiveness.

1. Coopressor stall of aircraft engine under combat firing conditions.

2. Limited to four and one half seconds of fire.

3. Limited to use of only two guns above 35,000' (an unsatisfactory attempt to prevent compressor stall).

In spite of these limitations a ratio of 6 Mig-15's destroyed, 3 Mig-15's probably destroyed and 10 Mig-15's damaged as opposed to two F-86 Gun Val aircraft damaged in combat was achieved. This indicates a high gun effectiveness. In my opinion when the present limitations are removed, the 20 mm gun should be installed in our fighter aircraft. This installation will then result in a definite increase in armament combat effectiveness.

HEADQUARTERS
FAR EAST AIR FORCES
APO 925
c/o Postmaster, San Francisco, California

SUBJECT: Concurrence in Final Report of Project Gum-Val

TO: Commanding General
Air Proving Ground Command
Eglin Air Force Base, Florida

The findings, as submitted in the final report on the Korean phase of Project Gum-Val, have been reviewed by the Commanding General, Far East Air Forces, and the conclusions and recommendations are concurred in.

FOR THE COMMANDING GENERAL:

JACOB E. SMART
Brigadier General, USAF
Deputy for Operations

ADDITIONAL DISTRIBUTION LIST

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Commander, Air Materiel Command, Attn: Mr. Dennie Haber, Wright Patterson AFB, Ohio	1
Commander, Air Force Armament Center, Attn: Capt. E. G. Roser, Eglin AFB, Fla.	1
Commander, FEALOG FOR, Attn: AMLRN-2, APO 329 c/o P. M., San Francisco, Calif.	1
Institute for Air Weapons Research, Museum of Science & Industry, Attn: Mr. John W. Wester, Jr., University of Chicago, Chicago 37, Illinois	1
Office, Chief of Ordnance, Department of the Army, Attn: Col. R. R. Studler, ORDTS, Washington 25, D. C.	1
Colonel O. H. Johnson, Director of Requirements, Far East Air Forces, APO 925, c/o P.M., San Francisco, Calif.	1

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

FEB 19 2002

MEMORANDUM FOR DTIC/OCQ (ZENA ROGERS)
8725 JOHN J. KINGMAN ROAD, SUITE 0944
FORT BELVOIR VA 22060-6218

FROM: AFMC CSO/SCOC
4225 Logistics Avenue, Room S132
Wright-Patterson AFB OH 45433-5714

SUBJECT: Technical Reports Cleared for Public Release

References: (a) HQ AFMC/PAX Memo, 26 Nov 01, Security and Policy Review, AFMC 01-242 (Atch 1)

(b) HQ AFMC/PAX Memo, 19 Dec 01, Security and Policy Review, AFMC 01-275 (Atch 2)

(c) HQ AFMC/PAX Memo, 17 Jan 02, Security and Policy Review, AFMC 02-005 (Atch 3)

1. Technical reports submitted in the attached references listed above are cleared for public release in accordance with AFI 35-101, 26 Jul 01, *Public Affairs Policies and Procedures*, Chapter 15 (Cases AFMC 01-242, AFMC 01-275, & AFMC 02-005).

2. Please direct further questions to Lezora U. Nobles, AFMC CSO/SCOC, DSN 787-8583.

Lezora U. Nobles

LEZORA U. NOBLES
AFMC STINFO Assistant
Directorate of Communications and Information

Attachments:
1. HQ AFMC/PAX Memo, 26 Nov 01
2. HQ AFMC/PAX Memo, 19 Dec 01
3. HQ AFMC/PAX Memo, 17 Jan 02

cc:
HQ AFMC/HO (Dr. William Elliott)

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE OHIO

JAN 17 2002

MEMORANDUM FOR HQ AFMC/HO

FROM: HQ AFMC/PAX

SUBJECT: Security and Policy Review, AFMC 02-005

1. The reports listed in your attached letter were submitted for security and policy review IAW AFI 35-101, Chapter 15. They have been cleared for public release.

2. If you have any questions, please call me at 77828. Thanks.

JAMES A. MORROW
Security and Policy Review
Office of Public Affairs

Attachment:
Your Ltr 14 January 2002

14 January 2002

MEMORANDUM FOR: HQ AFMC/PAX
Attn: Jim Morrow

FROM: HQ AFMC/HO

SUBJECT: Releasability Reviews

1. Please conduct public releasability reviews for the following attached Defense Technical Information Center (DTIC) reports:

   a. *Flight Test Program for Model P-86 Airplane Class – Jet Propelled Fighter*, 2 December 1946; DTIC No. AD-B804 069.

   b. *Physiological Recognition of Strain in Flying Personnel: Eosinopenia in F-86 Combat Operations*, September 1953; DTIC No. AD- 020 375.

   c. *Phase IV Performance Test of the F-86F-40 Airplane Equipped with 6x3-inch Leading Edge Slats and 12-inch Extensions on the Wing Tips*, May 1956; DTIC No. AD- 096 084.

   d. *F-86E Thrust Augmentation Evaluation*, March 1957; DTIC No. AD- 118 703.

   e. *F-86E Thrust Augmentation Evaluation*, Appendix IV, March 1957; DTIC No. AD- 118 707.

   f. *A Means of Comparing Fighter Effectiveness in the Approach Phase*, October 1949; DTIC No. AD- 223 596.

   g. *War Emergency Thrust Augmentation for the J47 Engine in the F-86 Aircraft*, August 1955; DTIC No. AD- 095 757.

   h. *Operational Suitability Test of the F-86F Airplane*, 4 May 1953; DTIC No. AD-017 568.

   i. *Estimated Aerodynamic Characteristics for Design of the F-86E Airplane*, 26 December 1950; DTIC No. AD- 069 271.

   j. *Combat Suitability Test of F-86F-2 Aircraft with T-160 Guns*, August 1953; DTIC No. AD- 019 725.

2. These attachments have been requested by Dr. Kenneth P. Werrell, a private researcher.

3. The AFMC/HO point of contact for these reviews is Dr. William Elliott, who may be reached at extension 77476.

JOHN D. WEBER
Command Historian

10 Attachments:
a. DTIC No. AD-B804 069
b. DTIC No. AD- 020 375
c. DTIC No. AD- 096 084
d. DTIC No. AD- 118 703
e. DTIC No. AD- 118 707
f. DTIC No. AD- 223 596
g. DTIC No. AD- 095 757
h. DTIC No. AD- 017 568
i. DTIC No. AD- 069 271
j. DTIC No. AD- 019 725